Mawtin Coast Partnership for Capacity Building for Coastal Biodiversity Monitoring MARINE AND COASTAL BIODIVERSITY OF THE MAWTIN COAST SURVEY RESULTS AND CONSERVATION RECOMMENDATIO...

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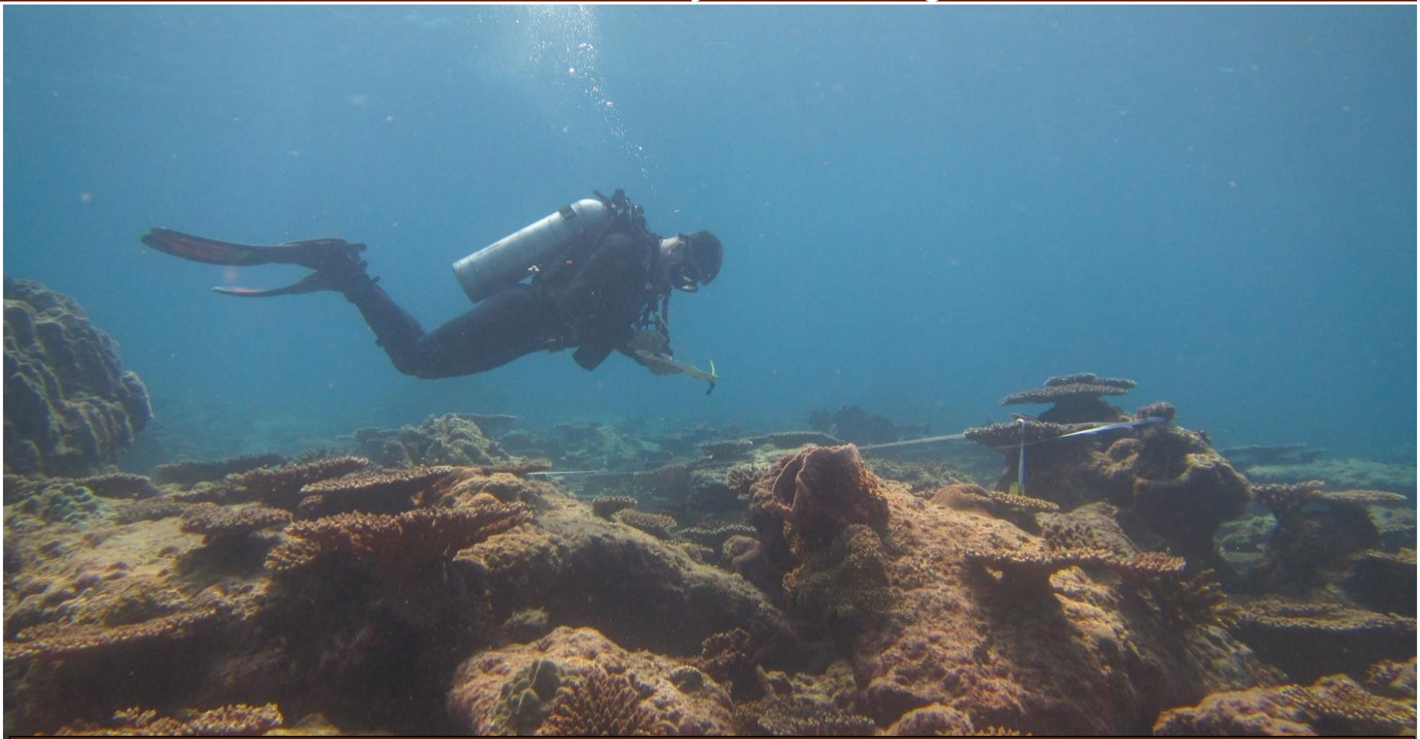
1 author:

Sue Murray-Jones
Fauna and Flora International

Mawtin Coast Partnership for Capacity Building for Coastal Biodiversity Monitoring



MARINE AND COASTAL BIODIVERSITY OF THE MAWTIN COAST

SURVEY RESULTS AND CONSERVATION RECOMMENDATIONS 2016-2020

Edited by **SUE MURRAY-JONES**

October2020

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Authors and Contributors

U Aung Aung Aye
Lecturer, Myeik University

Saravana Ayyappan
A/Professor, Annamalai University, India

Stefano Cannicci
A/Professor, University of Hong Kong

Filippo Carli
Marine Programme Manager, FFI: 2019-20

Daw Cherry Aung
Professor, Pathein University

Grace Frank
FFI Field Coordinator 2019

Robert Howard
Marine Programme Manager, FFI: 2016-2019

U Htay Aung
Liaison Officer, FFI and World View International

Maylene Loo
Maytrix Solutions

David Miller
South Australian Department of Environment

Daw Moe Lwin Lwin
Lecturer, Sittway University (formerly from Myeik)

Sue Murray-Jones
Programme Coordinator and Marine Advisor, FFI: 2016-20

Salai Mon Nyi Nyi Lin
Marine Biologist, FFI

Saw Moses
FFI/Independent Consultant

U Soe Htun
Marine and Freshwater Programme Manager, FFI: 2019-20; President, Marine Science Association, Myanmar

Soe Tint Aung
Marine Biologist, FFI

Arumugm Muthuvel
Annamalai University, India

U Thura Tun
Lecturer, Sittwe University (formerly Pathein)

Daw Thu Thu Min
Associate Professor, Pathein University

Daw Tin Tin Kyu
Lecturer, Myeik University

James True
King Mongkut's Institute of Technology, Thailand (formerly Prince of Songkla University)

Daw Yin Yin Htay
Associate Professor, Myeik University

U Zau Lunn
Marine and Freshwater Programme Manager, FFI: 2016-18

Christoph Zöckler
Manfred Hermsen Foundation, Bremen, Germany

Note: Many students and staff, in particular from Pathein University Marine Science Department, assisted in many ways and participated in training. Only those who made a significant contribution (such as collecting significant amounts of data, mapping, writing, editing or data analysis) have been credited as a contributor.

Mangrove training. Photo: Grace Frank/FFI

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Fauna & Flora International-Myanmar (FFI) would like to thank the Government of the Republic of the Union of Myanmar. We are thankful to the Department of Fisheries of the Ministry of Agriculture, Livestock and Irrigation, especially to Director General U Wai Lin Maung, Deputy Director General U Myint Zin Htoo, Retired Director General U Khin Maung Maw, Retired Director U Soe Myint, Former Director of the Research and Development Division U Tun Win Myint, Current Director of the Research and Development U Aung Nyi Toe for kindly guiding to develop this publication and tireless support of Deputy Director Dr. Htun Thein and Staff Officer Dr. Thet Yu Yu Swe from the Research and Development Division to implement field activities. We also thank the Forestry Department (Ministry of Natural Resources and Environmental Conservation).

In particular, we would like to thank the heads (and the rectors) of all the marine science departments of Myanmar's universities (Pathein, Mawlamyine, Myeik, and Sittway) for encouraging students and staff to participate, helping develop programmes, and supporting training events and surveys. In particular we thank Professor Cherry Aung (Head of the Marine Science Department of Pathein University) and U Htay Aung (retired head, Pathein University and World Vision), without whom none of this work would have been possible. We really appreciate the enthusiastic participation in the research and training from the hundreds of staff and students from the Myanmar marine biology community who participated in the Mawtin Coast Partnership for Capacity Building for Coastal Biodiversity Monitoring.

Special thanks go to Professor Marti Anderson and the Primer-e team for support with PRIMER and for providing the programme at such a heavily discounted price.

FFI also extends its appreciation to all researchers who contributed to the production of this biodiversity report and provided the training that made the work possible. A final thank you to all the FFI staff who worked so hard on planning and running the field research, notably FFI's marine team: U Soe Htun, Salai Mon Nyi Nyi, Soe Tint Aung and Antt Maung, as well as the accounts team who helped manage the small grants funding. The report would also not be possible without all the supporting staff both current and former including Robert Howard, Filippo Carli, U Zau Lunn, Ben Carroll, Mark Grindley, Frank Momberg, Gurveena Ghataure, Carl Reeder and Patrick Oswald, as well as all the office staff in Yangon and Myeik.

Forewords

Director General, Department of Fisheries

I am pleased to have the opportunity to write this foreword for the "Marine and coastal biodiversity of the Mawtin Coast: Survey results and conservation recommendations" report. This important work was done by the collaborating arrangement with the Department of Fisheries (DoF) and Fauna and Flora International (FFI) for the purpose of the conservation and management of marine resources in Myanmar's coastal areas.

A key focus of the Mawtin Coast Partnership to Strengthen Capacity Building for Coastal Biodiversity Monitoring has been developing the skills and providing the necessary equipment to enable the next generation of Myanmar's marine biologists to continue to assess, monitor and manage our marine assets. Fisheries Officers were included in much of the training.

This report is a collective effort from a team of Myanmar's scientific researchers, students, government officers and NGO staff supported by international researchers. They have undertaken many days of training and data collection with the key aims of ensuring we understand the status of the Mawtin coast's habitats and to collect information to guide management. This has included detailed surveys of some coral reefs, as well as seagrass beds and mangrove habits, which are important fish nursery grounds and habitats. This research has been summarized in a number of detailed technical reports, which have now been incorporated into this report.

The report now provides the government of Myanmar with detailed knowledge of the marine and coastal assets of this part of the coast and its marine life. There are also a number of recommendations which will enable the government, both national and regional, and its partners, in conjunction with local communities, to ensure the country meets its biodiversity targets and most importantly ensures sustainable management of Myanmar's precious marine resources. This report also highlights some of the threats to the coastal areas, from over exploitation of its resources to impacts from climate change. Without a clear understanding of the status and threats of the area it would be difficult to manage these issues.

This report summarizes the information with scientific rigour and clarity and will provide a good reference for the fishery area of the country now and in the future.

Wai Lin Maung
Director General
Department of Fisheries
Ministry of Agriculture, Livestock and Irrigation
Republic of the Union of Myanmar

Rector, Pathein University

Myanmar borders the Andaman Sea and the Bay of Bengal with a coastline of approximately 2400 km and is strategically located near the Indian Ocean. In line with the fact that Myanmar possesses large inland and marine fisheries and aquaculture resources, it is crucial to move towards a sustainable marine and inland economy.

Present project reveals the marine and coastal biodiversity of the Mawtin Coast, which is the west coast of Ayeyarwady Region and the southern part of the Rakhine Coastal Region. In particular, Mawtin Point, situated within the project site, is formally known as Cape Negrais and is a famous landmark in the Ayeyarwady Region and it also marks the south west of Myanmar. Despite being a country landmark, surveying and gathering baseline data in such an area have been very limited and there is a shortage of biodiversity and habitat information.

Since 2016, Fauna & Flora International (FFI), a conservation non-government organization, has been collaboratively working with Myanmar universities, located in coastal areas with the main purposes of data collection on sub tidal and coastal habitats; and capacity building. From this collaboration during 2016 and 2020, many staff and students from Marine Science departments of Pathein, Mawlamyine, Myeik and Sittway universities achieved significant exposures to training by national and international experts and supported by conducting seminars, training, and workshops and through the small grants.

By these initiative achievements, we truly look forward to taking steps towards efficient planned developments and well-governed conservation management, supported by various stakeholders including international development partners so that many benefits, social, environmental, financial will be gained for better future in coastal areas with rich natural resources in Myanmar.

On behalf of Myanmar universities, especially Pathein University, we would like to record our sincere thanks to Fauna & Flora International for initiating this important project and to assist all the staff and students in each and every steps. In particular, Mark Grindley, Myanmar Program Director, FFI and Sue Murray-Jones, Program Coordinator and Marine Advisor, FFI for their leading role and generous moral and technical support to the project. We hope the outcomes of this project will inspire other researchers for their noble thoughts on sustainable conservation management of coastal resources.

Professor Si Si Hla Bu
Rector
Pathein University
Ayeyarwady Region
Myanmar

Seagrass survey team

Executive Summary

This report summarizes biodiversity data collected during the Capacity Building for Coastal Biodiversity Assessment Partnership, a project based on the Mawtin coast of Myanmar (which comprises the west coast of Ayeyarwady Region). The partnership has had two key aims: the collection of data on subtidal and coastal habitats; and the building of capacity in the local university system to undertake future marine survey work and impact assessments, particularly at the Marine Science Department of the University of Pathein, Ayeyarwady Region.

International and national trainers were employed to teach specific survey methods and species identification, as well as to collect data, while general training, practice and supervision was provided by Dr Sue Murray-Jones, under the auspices of Fauna & Flora International, a UK-Based conservation agency with a strong presence in Myanmar. Training and surveys to date have included corals (with associated invertebrates, fish, anthropogenic impacts and resilience assessments), seagrasses, mangroves, birds, environmental impact assessment, and underwater video habitat mapping, as well as a whole range of building competency, from swimming to basic computer and mapping skills. The Partnership provided a total of 4337 training days between January 2016 and January.

Corals: The reefs of the Mawtin Coast of Myanmar are not true coral reefs, but rather rocky reefs with some coral. Mean hard coral cover from 14 sites surveyed ranged between 69% (± 10sd) to 9% (± 6sd), and was very patchy (varying from 3% to over 80% at a 20m long transect level. Turbidity is high in the region, which confines corals to shallow water and limits growth. Coral diversity was generally low, with mainly *Acropora* and *Porites* species (3-4 species of each). Coral communities are generally low in profile, suggesting that seasonal storms and wave surge exert strong pressures on the corals. Numbers of fish were very variable but generally low, and few invertebrates on the Reef Check set of indicator species were recorded. No sharks, marine mammals, mantas or dugongs were seen at any time, and only two Hawksbill turtles were seen (including from boats, beaches and in the water). Crayfish were rare, and those seen were generally very small. The best sites (most diverse, most fish, highest coral cover) were those in deeper water, on more offshore reefs, particularly offshore from Ngwe Saung. Resilience assessments by Dr James True were completed in 2016 and 2019, providing a full description of the coral communities for some key biodiversity areas. There was evidence of coral disease, and many reefs appeared to be recovering from a past mortality event.

Seagrass: Overall around 80 sites were inspected for seagrass, but only 12 sites were quantitatively surveyed, either due to no seagrass being present, small patch size, rough weather or very low visibility. Seagrass surveys were conducted in March and November 2016, and in February 2018. Distribution of seagrasses at sites surveyed was very patchy, ranging between 0 and 100% cover at the quadrat level, and 3 and 69% at the transect level. Mean cover between sites ranged from 12% (± 3, s.e.) to 67% (± 7, s.e.), with a mean cover for all sites of 41.1% (± 6, s.e.). In all, ten species were found. Only one site, Pho Htaung, had all 10 species. The most common species were *Halodule pinifolia*, which was found at eight sites, and *H. uninevis*, which was found at seven sites. No sites were monospecific. There was a mean number of 4.8 (±1, s.e.) species per site, varying from two to ten species.

Mangroves: Training and surveys of mangrove habitat was conducted in 2018 and 2019. Surveys were carried out in four forests along the Mawtin coast. The mangrove sites were both highly biodiverse and greatly degraded. Overall, we recorded twenty-five species of true mangroves, four of which are listed as Nearly Threatened (*Aegialitis rotundifolia, Ceriops decandra*), Endangered (*Heritiera fomes*) or Critically Endangered (*Sonneratia griffithii*) on the IUCN Red List, and five mangrove associated species, one of which is listed as Nearly Threatened (*Phoenix paludosa*). At all sites, mangroves were deeply impacted, with almost all trees recorded represented by either young specimens or trees recovering from major cut.

Birds: A total of 163 bird species were recorded in the eastern delta and along the Mawtin coast in February 2016, while 118 were recorded in the Meinmahla Kyun Wildlife Sanctuary and adjacent outer delta islands in the Ayayarwady Delta in December 2016. Among these were fifteen species globally classified as near-threatened, vulnerable or endangered. Three species, Long-legged

Buzzard, Sooty Tern and Asian Glossy Starling were observed for the first time in the Ayeyarwady Region. A rare subspecies of the Blue Rock Thrush, *Monticola philippensis,* was also observed for the first time along the coast in Myanmar. Mangroves were observed to be highly degraded and subjected to logging and timber extraction for charcoal production. A brief characterization of mangrove condition was included. ERA and ArcCona Consulting produced a report using satellite images (along with the characterization of mangrove condition) to classify vegetation and land use [1].

Habitat mapping: We ran habitat mapping training and surveys in 2018 and 2109 in key biodiversity areas identified for the Mawtin Coast. With the assistance of the trainees, we mapped benthic habits around White Sand Island, Nya Yoke Kaung, the Bird Islands, Ma Gyi, Wetthe, Poe Laung and Pho Htaung. The dominant habitats seen were sand and rocky reefs. Some areas of reef supported good coral cover.

Conservation recommendations: In this chapter, we discuss some specific threats to some of the different habitats described in this report, and make some recommendations to ameliorate or manage these threats.

Students with Professor U Soe Htun (white shirt) travelling to field site during seagrass training.

[1] Harris, C., Lorenz, K. and Zöckler, C. (2016). Land Cover Classification, Mawtin Coast, Ayeyarwaddy Region, Myanmar.

1. INTRODUCTION

Author: Sue Murray-Jones

1.1 Background

Fauna & Flora International (FFI) is a UK-based conservation organisation which has been operational in Myanmar since 2006, with a focus on strengthening civil society participation in biodiversity conservation. WFFI's work was initially mainly terrestrial, and many surveys of key biodiversity areas were carried out. FFI recognised that equivalent opportunities for conservation existed in Myanmar's coastal and marine areas. This led to discussions in 2012 with the Myanmar Department of Fisheries and the Ministry of Natural Resources and Environmental Conservation on the specific needs to develop the sustainable management of marine and coastal areas and establish an effective network of protected sites, including creating Myanmar's first models for local marine and coastal management. Since that time FFI has undertaken extensive assessments of coral reef, seagrass and mangrove habitats throughout Myanmar's Myeik Archipelago and have created the country's first Locally Managed Marine Areas with local communities and the Department of Fisheries.

The Capacity Building for Coastal Biodiversity Assessment Partnership is a collaboration between Fauna & Flora International (FFI) and the Marine Science Departments of Myanmar's universities. The partnership has two key aims: collection of data on subtidal and coastal habitats; and building capacity to undertake future marine survey work and impact assessments.

This project was initially conducted in partnership with the University of Pathein's Marine Science Department but was later extended to work with all four of the marine science departments in Myanmar, i.e. Pathein, Myeik, Sittway and Mawlamyine Universities. These universities offer higher degrees in Master of Science, Master of Research, and Doctor of Philosophy (note that not all universities offer all programmes. For instance, in the biosciences, Pathein University only offers a PhD programme in Microbiology, while Mawlamyine University is the only university which offers PhDs in Marine Science).

Myanmar has a long coastline of around 2400 km with many marine resources, and is thought to be one of the most undeveloped coastlines in mainland Southeast Asia (Holmes *et al.* 2013). The coast is generally divided into three coastal regions: the Rakhine Coastal Region (from the mouth of the Naaf River to Mawtin Point, about 740 km in length), the Ayeyarwady Delta and the Gulf of Mottama, about 460 km in length) and the Tanintharyi Coastal Region (from the Gulf of Mottama to the mouth of the Pakchan River, about 1200 km in length (FAO 2003). The country is undergoing a rapid transition to democracy, which is providing many opportunities for international investment and development, which is likely to create pressures on an environment for which there is very little baseline information.

The focus area of the partnership is the Mawtin coast of Myanmar, which is the west coast of Ayeyarwady Region—the southern half of the Rakhine Coastal Region. The Mawtin Coast extends from Gwa in the north to Mawtin Point in the south (see Figure 1.1).

Phase I and II of the project have been documented in detailed reports (Murray-Jones *et al.* 2017, 2018, 2019)[2]. This current report summarizes all the biodiversity data collected during the partnership.

A key component of the partnership was to set up a small grants scheme, to mentor, train and encourage students and staff to conduct research in the focus area.

[2] Available on request from Fauna & Flora International: www.fauna-flora.org

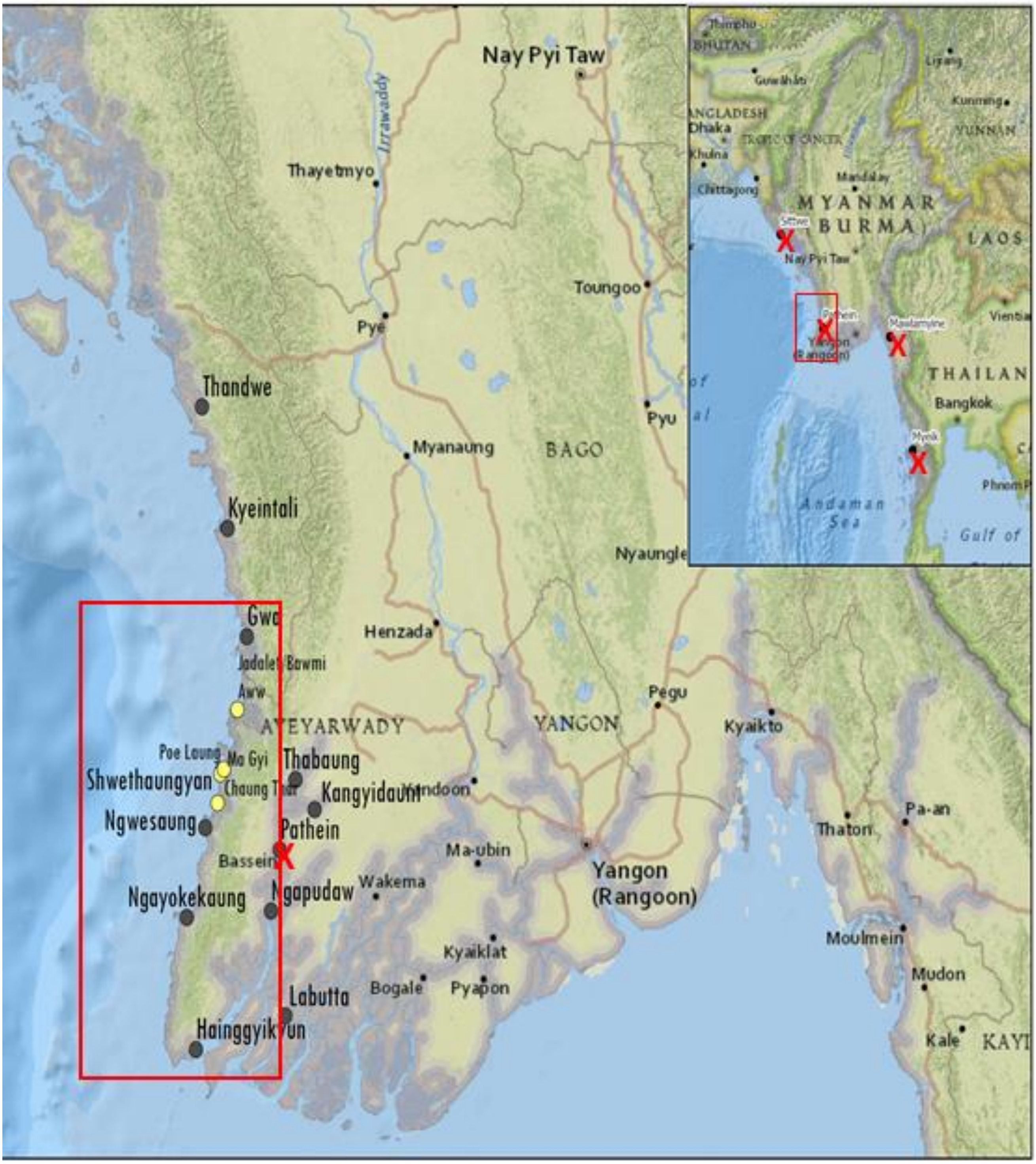


Figure 1.1: Map showing location of the focus area, the Mawtin coast of Myanmar, and the location of the four universities with marine science departments (red crosses).

1.2 Current baseline information

Baseline information on the marine resources and habitats of the Rakhine Coast (the west coast of Myanmar encompassing both Ayeyarwady Region and Rakhine State, see Figure 1.1) at the start of the Mawtin Coast partnership was sparse. There was little information on the coasts of Myanmar in international journals, especially for the Rakhine coast, although there is information available internally. Various Myanmar Government departments and university researchers have conducted studies on a wide range of the country's marine resources and habitats, including MSc and PhD research. Many of these studies have not been published and are difficult to access. There are many NGOs (e.g. WCS Myanmar, IUCN) working alongside Myanmar researchers to document information and provide conservation recommendations, and some material is now online.

The abstracts of 416 theses and papers published in Myanmar journals before 2013, such as the Universities Research Journal and the Journal of the Myanmar Academy of Arts and Sciences, have been complied into a publication, Myanmar Marine Biological Abstracts (Tint Tun *et al.*, 2013), which highlights the research interests of the various universities. These abstracts, along with the many MSc and PhD theses (which are generally written in English), contain much valuable information, although they are not yet generally available outside Myanmar, nor published electronically.

In general most of these studies are very locally focussed and usually look at single sites, with no spread of geographic locations nor comparative studies. A sampling of theses shows many such examples, such as a description of the infauna of one tidal mudflat (e.g. Thu Ya Kyi Zin 2016); the mangrove community of one tidal creek (e.g. Htoo Lwin Aung 2016); the phytoplankton of a particular estuary or area (e.g. Ngo Min Thway 2016); or the seagrasses of one coastal area (Thu Rein 2018). This is reinforced by looking at the abstracts in Tint Tun *et al.* (2013), although a few studies do take in a wider area. Studies are often based on descriptive work, such as anatomy, histology and morphology (31% of theses to 2013) and taxonomy and systematics (18% of theses) as well as local inventories of various taxa (19% of theses, Holmes *et al.* 2013). This is likely to be due to a lack of resources, as no funding is available for students or staff to do field work, as well as a lack of emphasis on manipulative studies.

Generally, habitat descriptions across wider areas are lacking. Studies also rarely include replication of sites or comparisons between sites, or between years. Few assessments directly investigate the status of marine species, with the exception of fish species that are the target of various fisheries, and there are few experiments conducted.

In 2013, Holmes *et al.* (2013) complied over 600 papers and reports (including 348 theses) relating to Myanmar's marine biodiversity and habitats for the Wildlife Conservation Society (WCS). Much of this information has also been complied into an accessible web-based report (Holmes *et al.* 2014), and we have drawn heavily on these resources for background information. Other resources are catalogued on the WCS searchable Myanmar Marine Reference Database, and the Bay of Bengal Large Marine Ecosystem (BOBLME) Project (a collaborative project between FFI, WorldFish and FAO). The Myanmar Marine Biodiversity Atlas contains some useful background information (Birch *et al.* 2016).

In a workshop in 2012, WCS identified the coastal areas of southern Tanintharyi Region and the Rakhine Coast as important "Conservation Corridors" that encompass and link Key Biodiversity Areas (Wildlife Conservation Society 2013). In each of these two priority corridors, WCS conducted simple ecological assessments and habitat mapping, along with stakeholder interviews, and contributed to the development of a GIS database focusing on the coastal habitats of Myanmar; however, these appear to have been restricted to the Thandwe District of Rakhine state, north of Gwa, and did not include the Mawtin coast, and are hence outside the area of focus for the current project.

FFI has trained a number of Myanmar nationals as SCUBA divers, who have been employed on local projects for FFI since 2012; however, until recently, there has been limited SCUBA diving capacity within the universities in Myanmar, with only a few university personnel from Mawlamyine and Myeik trained by FFI in 2014. Many marine scientists in Myanmar have limited swimming skills, and indeed may be quite fearful of the water. Hence much of their research focus has been on accessible

nearshore habitats, such as mangroves or shallow tidal creeks. Typically, research on subtidal species has relied on specimens collected by fishermen, or in trawl nets (e.g. as noted in many abstracts in Tint Tun *et al.*, 2013); and there have been few subtidal assessments other than those conducted by NGOs such as FFI, and occasional visiting researchers. There has been some participation in scientific research cruises e.g. the oceanographic cruise of the Indian *RV Sagar Kanya*, from which some studies have been published e.g. Ansari (2012).

1.3 Survey model and capacity building

The model employed by FFI to deliver this project has been one of using international and national experts (where available) to conduct training for university personnel from the marine science departments, often assisted by Myanmar Fisheries Officers, with all training and surveys organised and supported by an international marine biologist (Sue Murray-Jones).

Where possible, survey data has been collected using university personnel, generally assisted by FFI divers; however, the university trainees are academic staff and students, and it is not possible for them to leave their duties for extended periods during the academic term. Hence some surveys were completed solely by FFI.

Phase I of the partnership (Jan 2016 – May 2017) focussed on building relationships with universities and government departments, training, data collection and the identification of key biodiversity areas. Because we found that trainees were lacking in some essential skills, particularly swimming, Phase II (June 2017 – May 2020) was more focussed on training. Training to date includes: assessment of mangroves, seagrass, corals, bird populations and mudflats; towed video habitat mapping; environmental impact assessment; as well as building skills in water safety, swimming and snorkelling, using a GPS and mapping, Excel, First Aid, grant writing and developing and costing projects (see summary table, Table 1.1).

One of the principal activities for Phase II was the development and initiation of a Small Grants Programme, of which there have been 25 to date (Table 1.1). This was designed to select suitable students and staff, provide assistance in grant writing, data collection and analysis, and give support, both financial and in the form of tutorials and mentoring (see Appendix 1)

Table 1.1: Training summary for Phase I and II of the Mawtin Coast Biodiversity Partnership.

Year/activity	2016	2017	2018	2019	2020	Total
Excel				42	24	66
1st Aid			31	20		51
Swimming, snorkelling	20	47	22	23	12	124
Diving	12		8			20
English	20	20				40
Writing grants				51		51
GPS				19		19
Statistics					14	14
Habitat mapping			21	23	48	92
Coral training	20			13		33
Mangrove training			22	34		56
Seagrass training	19	12	45		10	86
Impact assessment training		36				36
Bird training	44					44
Meiofauna training					11	11
Marine litter assessment		50				50

1.4 Geology

The western coast of Myanmar is a narrow strip of coastal land bounded by the Arrakhine Mountains. The study region consists of a relatively uniform geology, which is easily eroded into a complex coastal landscape comprising long, sandy beaches punctuated by bands of exposed rocks and low rocky islets (Metcalfe 2019, and Figure 1.1). Beaches are composed of fine sand, well compacted. The coast is seasonally exposed to fierce monsoon-driven storms, which resculpt the nearshore environment around the rocky platforms. The seabed slopes westward into the deep basin of the Bay of Bengal. There is no topographic bottom structure in the sea to the west of this coast to moderate wave development, and the gently-sloping shallow coastline is subject to severe wave action under the influence of the SW monsoon that blows across the entire Bay of Bengal.

1.5 Site selection

Little was known about the distribution of habitats on the Mawtin coast when the partnership began. Sites investigated in this report were initially selected based on local knowledge of sites (university personnel, FFI personnel as well as local boatmen and fishers), analysis of imagery, and accessibility. Much of the coast is not accessible by car, hence the weather and suitability of available boats was a factor in site selection. Boats were often too small to go far in the prevailing weather conditions on exposed coasts. We also found that local fishermen would assure us that there was seagrass at a particular place, but on inspecting the site, we found rock with algae, rather than seagrass, or rock with a few corals rather than the high cover of coral we were led to expect. Poor visibility in the water for much of the coast meant that imagery and aerial photographs were of limited use, including drone imagery (Murray-Jones *et al.* 2017).

This report covers a series of coral transects and coral resilience surveys, seagrass surveys, mangrove assessments, habitat mapping and bird surveys. Most of the effort was south of Gwa (within the area defined as the Mawtin coast); however, a few promising sites to the north of Gwa were investigated for seagrass, just outside the bounds of the Mawtin coast, but part of the southern Rakhine coast. We have also collected a small amount of data in the Tanitharyi region during training, which is not presented here.

1.6 Place names

Spelling of place names varies greatly in translation into English e.g. Phoetaung, Pho Taung, or Pho Htaung; Ngwe Saung, Ngwysaung, or Ngwe Saung. We have tried to at least be consistent, and where possible, used the spellings given by the Myanmar Information Management Unit for the Ayeyarwady Region; however, Myanmar colleagues often argue that these map names are themselves sometimes wrong, and some maps and tables do still have inconsistent spellings.

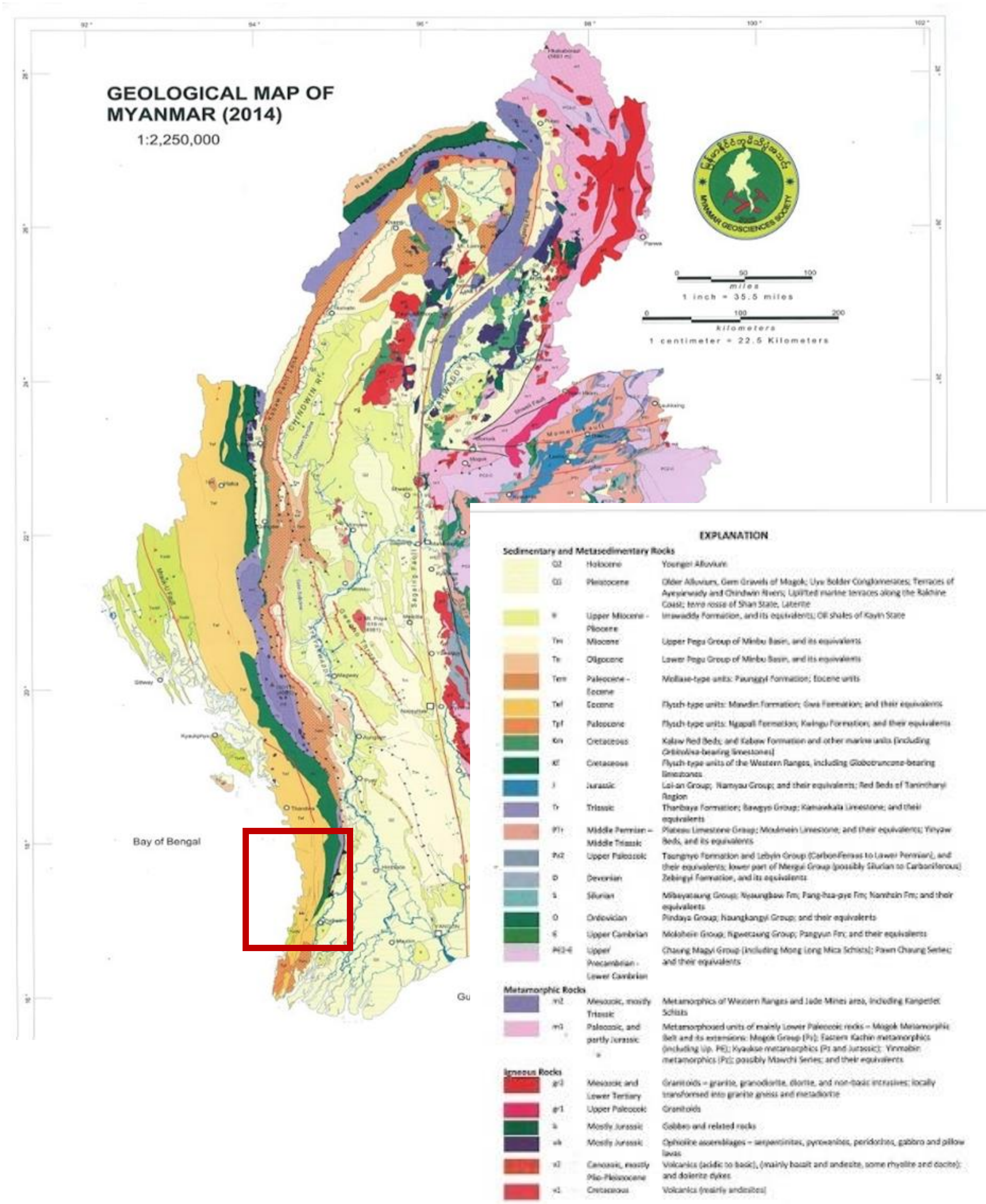
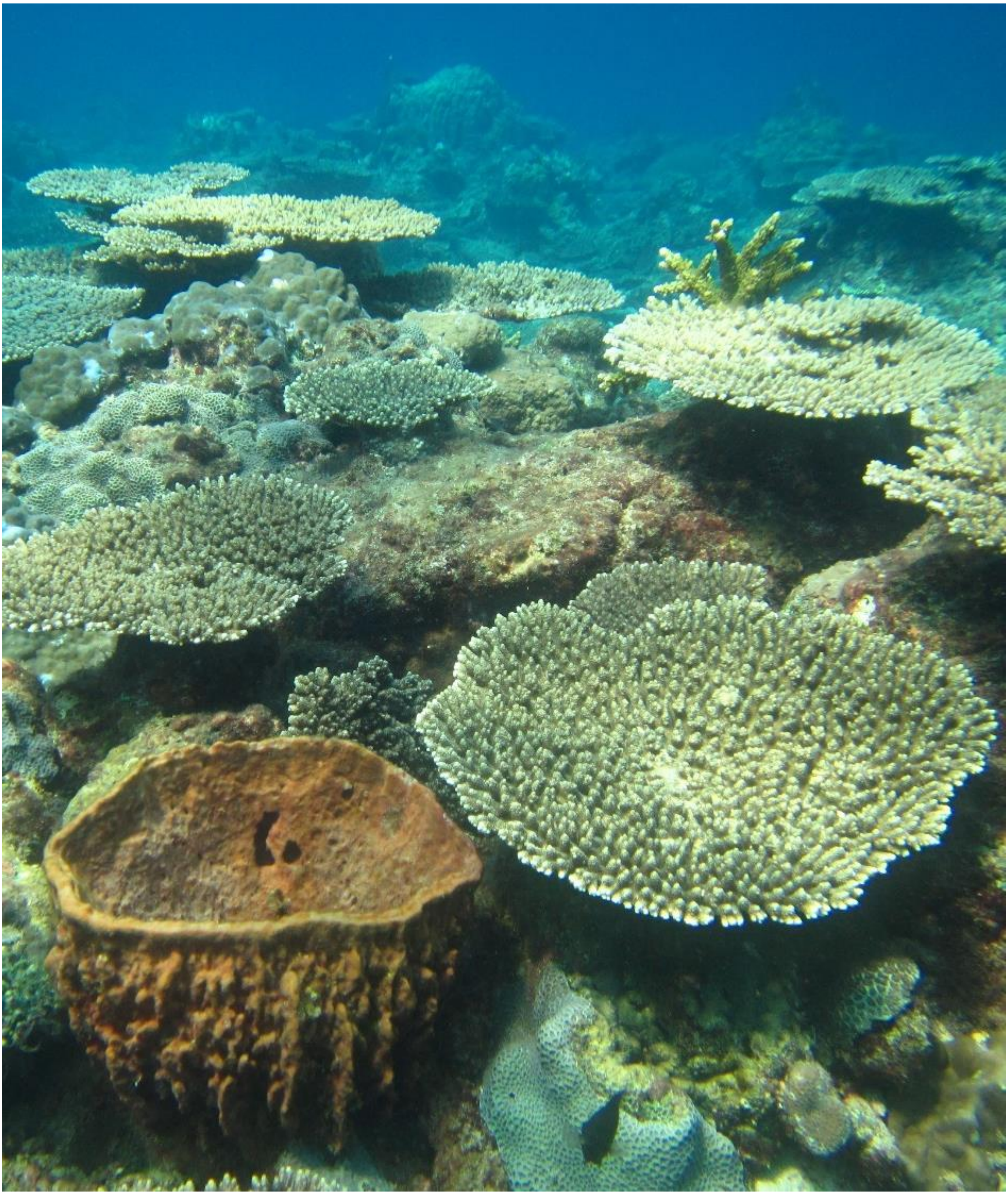


Figure 1.2: Key geological and tectonic elements of Myanmar and adjacent region (from Metcalfe 2017).



Coral gardens at North Bird Is, off Ngwe Saung

CHAPTER 2. CORAL COMMUNITIES

Authors: James True and Sue Murray-Jones

2.1 Introduction

The Global Coral Reef Monitoring Network data has suggested that even by 2008, approximately 19% of the world's coral reefs were already severely damaged, with 35% of the remainder at risk of degradation from direct human pressures (United Nations 2016). More recently, it has been suggested that over 60% of coral reefs world-wide are threatened (Burke *et al.*, 2011). Reefs and nearby seagrass and mangrove ecosystems are of major importance for 275 million people who depend on associated fisheries as their major source of animal protein (UN 2016), as well as depending on ecosystem services such as coastal protection (e.g. Wilkinson *et al.* 2006; Burke *et al.* 2011).

Threats to coral reefs are mostly a result of human activities and land use changes along coastlines adjacent to coral reefs. Threats to coral reefs are reasonably well understood, and include over-fishing (particularly using destructive fishing methods such as dynamite and cyanide fishing), which destroy reef structure; coastal development, which may increase the amount of silt and sediment in the water, as well as interrupting coastal processes and destroying mangroves; and pollution (both industrial, agricultural and sewage) (Burke *et al.* 2011, United Nations 2016). Threats to coral reefs are highest in South East and East Asia, with around 50 percent of reefs at high or very high threat levels, even before predicted impacts from climate change are taken into account (Burke *et al.*, 2011).

One difficulty in monitoring the condition of marine ecosystems in South East Asia is the lack of data, especially long-term data. In an attempt to standardise effort and collect data, the Global Coral Reef Monitoring Network is assisting many countries with assessment and monitoring of their coral reefs. Other networks for monitoring, awareness and protection are also organized by NGOs, such as Reef Check[3], which has been collecting data since 1998 and now operates in 90 countries (United Nations 2016) and is very active in South-East Asia. Since 1998 there has been an 80% increase in the threat from overfishing and destructive fishing worldwide (Burke *et al.*, 2011) along with increasing capacity to exploit resources (such as monofilament nets, hookahs, motor boats, and lights (United Nations 2016). Widespread overfishing for the live food and aquarium trade has led to a number of once-common reef fish being listed on the International Union for Conservation of Nature's (IUCN) Red List, e.g. the Humphead wrasse (*Cheilinus undulatus*) (de Mitcheson *et al.* 2013), which is why it has been added as one of the Reef Check indicator organisms (Hodgson *et al.* 2006).

An issue of primary concern for coral reefs is resilience, especially under a global warming scenario. Climate change is one of the greatest threats to coral reefs worldwide (Hoegh-Guldberg *et al.* 2007). Mass coral bleaching is one of the most obvious impacts of climate change on corals reefs, as high water temperatures trigger break down the coral-algal symbiosis. This can lead to mass coral mortality (Coles and Brown 2003).

Few data are available for the coral habitats of Myanmar, other than those contained in reports commissioned by FFI (e.g. Obura *et al.* 2014; Howard et al, 2014) for the Tanitharyi region. Lack of baseline data presents a real issue with the pace of development in Myanmar and the extent of the threats to reefs in Myanmar as for the rest of South East Asia.

The northern part of the Mawtin Coast of Myanmar is a narrow strip of land facing the Bay of Bengal, hemmed in by rugged coastal ranges to the east, and comprises a short section of the western Myanmar coast that transitions between marine ecosystems dominated by the massive Ayeyarwady river plume and a more purely maritime ecology. The section of the Mawtin coast between Ngwe Saung and Shwethaungyan (Ma Gyi) is home to an increasingly popular domestic coastal tourism industry, which is drawing investment and rapid development of the area, including construction of bridges and coastal roads, opening up previously inaccessible areas.

[3] www.reefcheck.org

In the northwest of Ayeyarwady Region, the coast is comprised of rocky ridges interspersed with wide beaches that provide ample opportunity for beach-focused tourism, prompting the division of the coastline into a myriad of resort frontages. In the north, much of the coast is largely undeveloped with poor transport infrastructure, but in many coastal areas there is high human population pressure on the environment. Transport and community infrastructure are generally poor in the region, with the exception of the main coastal tourist areas of Ngwe Saung and Chaung Tha beaches, which are connected by sealed road to the Ayeyarwady Region capital of Pathein, and are the closest beaches to the capital, Yangon (see map, Figure 1.1). Much of the historical use of the coast has revolved around cultivation of coconut, harvesting of mangrove timber and low intensity coastal agriculture, interspersed with small scale fishing operations using mostly nets, traps and hookah-equipped divers. Intensity of fishing operations has been sufficient to largely remove macropredators from reef environments, and to depauperize fish communities along the coast.

Over the past few years, increasingly active development of local (Myanmar) tourism has occurred, and there are ambitions to develop the area in a way to attract the lucrative foreign tourist dollar. The burgeoning tourism industry not only changes the characteristics of the coastal landscape and introduces issues of waste water management, but also creates strong demand for souvenirs and seafood to be sold to tourists. This exacerbates the severe overfishing problems affecting coastal ecosystems, but—somewhat paradoxically—also creates opportunity for partial recovery of some areas through diversion of fishermen into tourism-associated businesses, and marketing pressure to provide biologically rich environments to attract tourists. Although the vast majority of tourism is not reef-based, the rapid expansion of the tourism industry is likely to have an increasingly large impact on reef health.

Reef resilience is a term that refers to the ability of a coral assemblage to recover and persist in the face of impacts, whether from natural or anthropogenic sources. In a broader context, resilience refers to factors that may drive recovery or decline of a reef assemblage over time. Often these factors are symptomatic of wider issues; for instance, coral bleaching indicates prolonged stress events, such as elevated water temperature or hyposalinity. Certain factors may be used as indicators of trends in the "health" of the coral community, either through direct measurement of disease or ill-health indicators, or through proxy assessment of damage, regrowth and replenishment of colonies lost to mortality. Additional, non-coral proxies of community resilience, including the presence and absence of coral predators or habitat-maintaining guilds of fish or invertebrates can also be employed to gauge resilience.

Note that Shwethaungyan has been the focus of much effort during the partnership, partly because of the highly diverse ecosystems there, and partly because the University of Pathein has a field station at Ma Gyi, close to Shwethaungyan. Hence the university is particularly interested in collecting data from the area.

Information is scant for the western coast of Myanmar regarding coral communities, and none has been reported further south of Ngwe Saung than Goyangyi Rock (around 20km south of Ngwe Saung). Despite this, some relatively small amounts of coral were mapped during the 2018 habitat mapping surveys using towed underwater video around Nga Yoke Kaung, to the south of Ngwe Saung (Chapter 5).

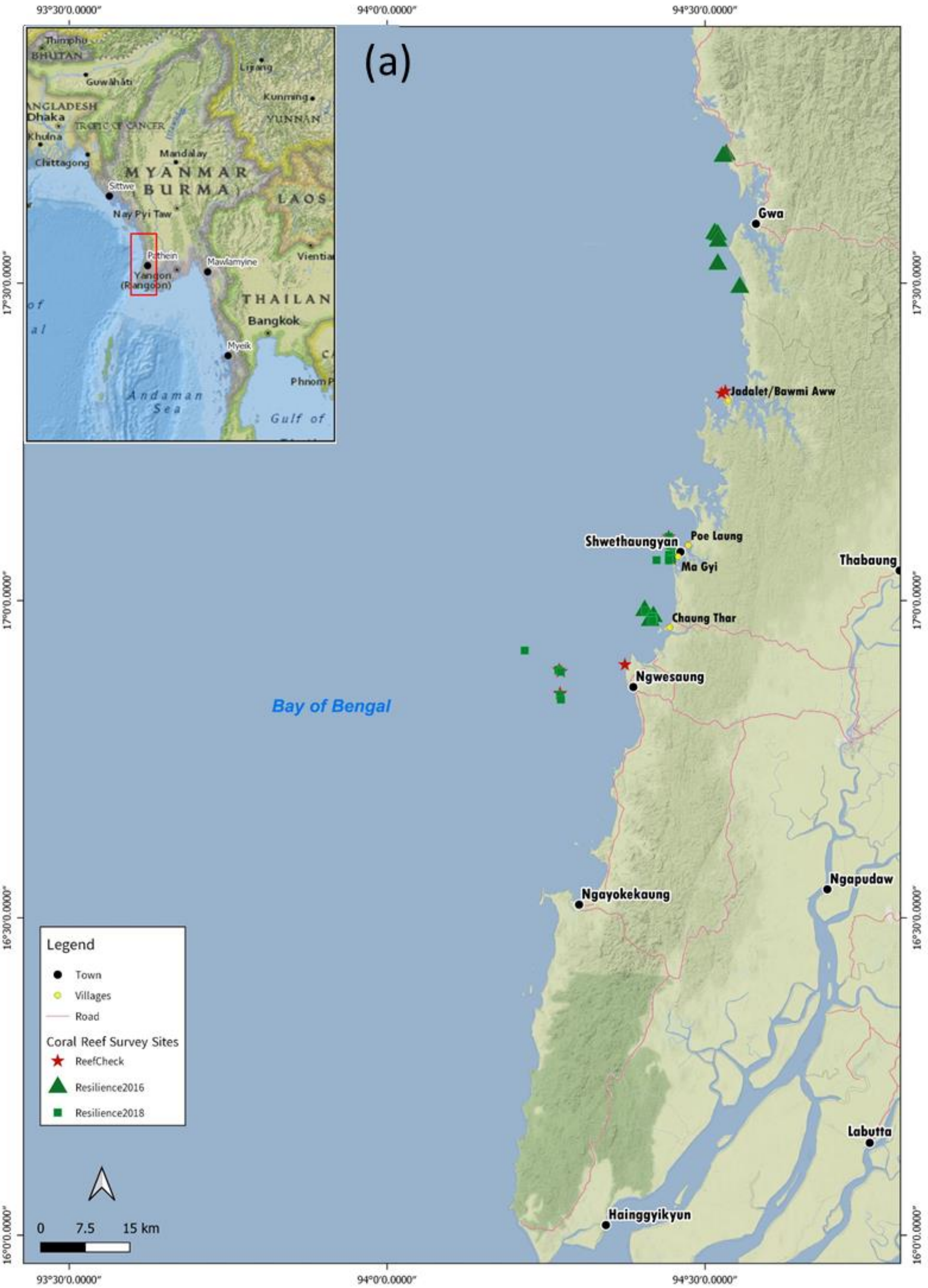
Four coral survey field trips were conducted, in February, April/May, and December 2016, and in February 2019. Reef Check surveys were completed in April/May and December 2016. Resilience assessments were conducted in 2016 and 2019.

2.2 Method

2.2.1 Site selection

In 2016, little was known about the distribution of coral on the Mawtin coast. Sites were selected based on local knowledge and talking to the fishing community. In Ngwe Saung, the local dive centre provided a guide and suggested suitable sites. In 2019, areas identified as key biodiversity areas were re-surveyed. Sites actually surveyed for 2016 and 2019 are shown in Figure 2.1(a). Altogether

we investigated 61 sites by either snorkelling or diving, and collected presence/absence data. All sites investigated are shown in Figure 2.1(b).



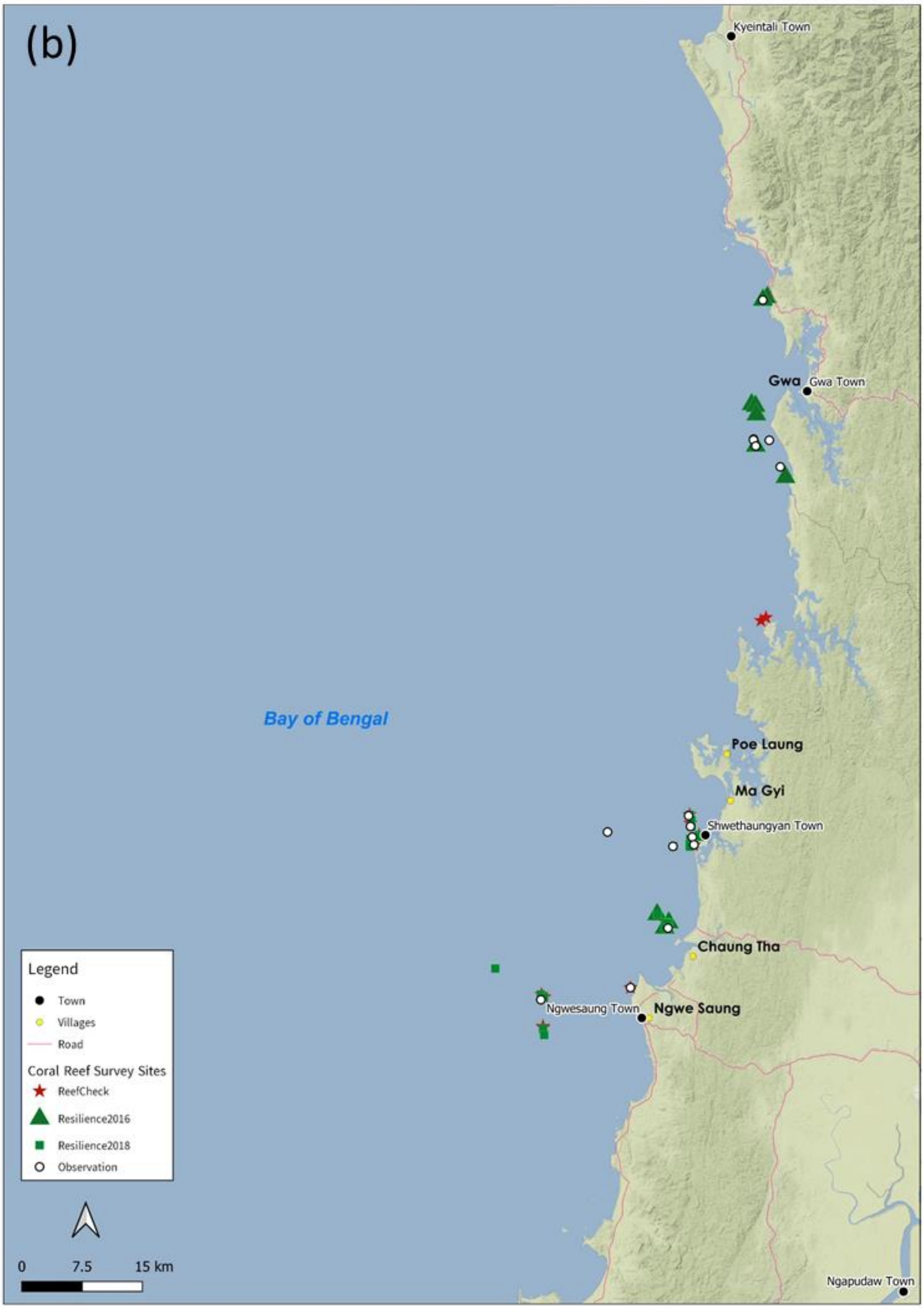


Figure 2.1: (a) Map showing sites dived during coral surveys. Symbols: red star, Reef Check transects; green triangle, resilience and training dives, 2016; green square, resilience and training dives, 2018; (b) Map showing all sites investigated. Open circles represent with presence/absence data only.

2.2.2 Transects

The Pathein University divers were trained in using Line Intercept Transects for a modified form of Reef Check assessments using the 31 lifeform codes developed by Karenne Tun at the Phuket Marine Biological Centre in 2010 (also generally used by FFI in previous surveys). However, due to the poor water skills of the trainees, and the lack of training time, we used the more standard Reef Check methodology (e.g. as used by Reef Check Malaysia) to conduct the Reef Check surveys, using 10 life form codes for the substrate assessments for the 2016 surveys (see Appendix 2). Using this simplified method allowed for better quality control for data collected by trainees, while developing their buoyancy skills. It also allows for regional comparisons. Reef Check includes an invertebrate and fish assessment using a limit set of organisms of indicator species, as well as anthropogenic impacts (Appendix 2). There is extensive literature by Reef Check behind the reasons these species are used (e.g. Hodgson *et al.*, 2006), and details are not given here. For the December 2016 surveys, which focussed on the islands offshore of Ngwe Saung, highly experienced FFI divers conducted the surveys, hence corals and a larger set of invertebrates were identified to family and species respectively, and for the resilience assessments and transect, corals were identified to family.

Typically in Myanmar, visibility is low and corals mostly confined to shallow water, especially on inshore reefs. On the Mawtin coast, there are no true coral reefs (although some reef accretion was visible at North Bird I); however, coral cover can be high. The lack of a reef slope means the standard Reef Check method of doing transects at two different depths is not possible. For this reason, FFI divers do five by 20m transects instead of the usual four, to increase replication. For each transect, the following data were recorded: site description; substrate using a point intercept method at 0.5m spacing; invertebrates, where a five metre width belt transect was surveyed for each 20m long transect and information on a specific set of indicator species was scored; anthropogenic impacts, coral disease and bleaching; and a specific set of indicator species of fish counted within a five metre width belt transect (see Appendix 2: Standard Reef Check Categories).

2.2.3 Resilience assessments

The 2016 resilience assessment was compiled after the first coral survey, and was not a quantitative assessment but rather a descriptive “first look” at the ecosystems and speculation about the major drivers of ecosystem resilience on the Mawtin Coast made by a trained and expert observer. Diving assessments that contributed were conducted around Gwa, at the northern end of the focus area, Jadalet and Bawmi Aww (about 30km north of Shwethaungyan), Shwethaungyan, Chaung Tha and Ngwe Saung (see Figure 2.1(a)).

In 2019, Shwethaungyan, Chaung Tha and Bird Islands off Ngwe Saung were resurveyed, and the assessed (see Figure 2.1(a)). For the 2019 resilience assessment surveys, two 25m transects were randomly deployed. Standard line intercept transects were recorded to highest possible taxon of coral, along with resilience factors: disease, ill-health indicators, physical damage, partial mortality, and growth stage. Notes were taken at the completion of the transects regarding fish and invertebrate assemblages and general notes on the condition or topology of the site.

Transect data were recorded as Microsoft Excel files, and descriptive statistics were undertaken in MS Excel.

2.3 Results

Results are compiled from consultants’ reports (Murray-Jones *et al.* 2016, 2019; True 2016, 2019) and are presented here first as data collected via simple Reef Check methods, carried out by university and FFI divers, followed by the resilience assessments.

2.3.1 Reef Check

Fifty sites were assessed in 2016, generally by snorkel initially. Fourteen Reef Check surveys were carried out, 11 in April/May, and three in December 2016. For other sites, a waypoint and brief description of the habitat was collected (Figure 2.1(a), (b)).

i Substrate

The communities were predominantly composed of hard corals, mainly robust tabular and digitate *Acropora* and massive *Porites* species. Little carbonate platform was apparent; coral communities were aggregations of colonies attached to bedrock, rather than true coral reefs. Communities of corals were not especially diverse; few communities had more than 20 species, across six families of hard corals.

Soft corals (mainly *Sinularia* sp.) were rare in most localities, making up between 0-2% of substrate. Mean hard coral cover ranged between 69% (±10sd) at Jadalet (the most northerly site), to 9% (±6sd) at South Bird Island in December (Figure 2.2); Coral cover was relatively high at both North (54% ± 6sd) and South (39% ± 9sd) Bird Islands in the first set of surveys, offshore from Ngwe Saung. At a transect level, coral cover was as little as 2.5% (South Bird I in December) to 83% at Jadalet, north of Poe Laung, and was very patchy (Figure 2.2). Due to this patchiness, and the fact that these are not true coral reefs, but rocky areas with some coral cover, detailed analyses on the data have not been performed.

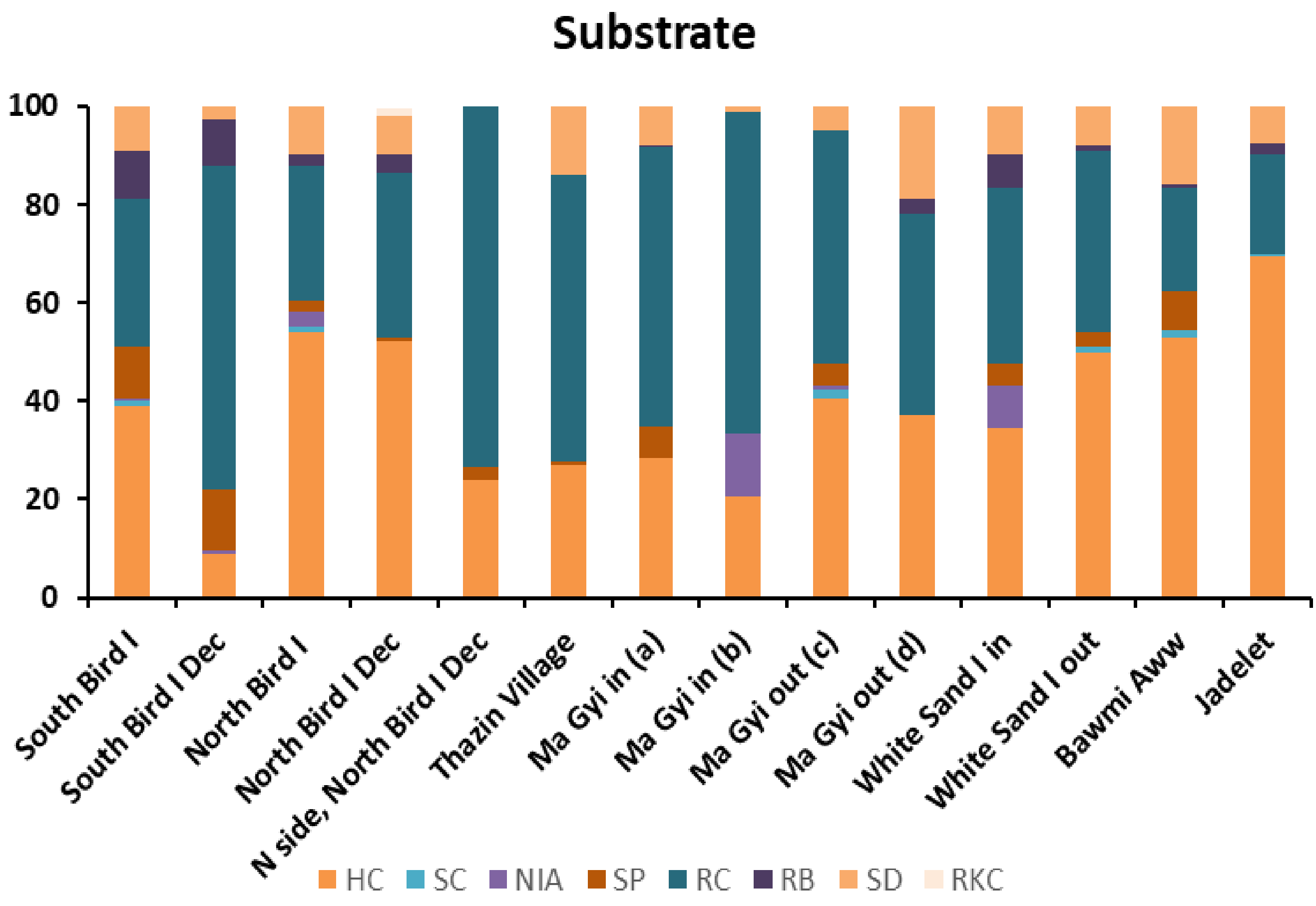


Figure 2.2: Percent substrate cover for 14 sites from the Mawtin Coast, Myanmar. Sites surveyed in April/May 2016 unless specified (December 2016), using basic Reef Check methods (point intercept method, means of 5 by 20m transects). Arranged from south to north.

ii Fish surveys

No sharks, turtles, mantas, marine mammals or any other rare animals were seen on any dive or snorkel, nor from any boat en route to dive sites, with the single exception of two Hawksbill turtles on a transect on the north side of North Bird Island in December 2016. Only one elasmobranch, a Blue-spotted ray, was observed in all dives. No Humphead wrasse or Barramundi cod were seen, either on or off transect, and only three large grouper (over 50cm) were seen, on a single site on the north side of North Bird Island in December. Moray eels were only seen at Thazin Village, Chaung Tha (White Sand Island), and South Bird Island, and only a single eel was seen on a single transect at each of these sites. We found a mean number of 50 fish (±61sd) per transect. South Bird I in April had the highest fish count, with 126 (±130.5sd) fish per transect (Figure 2.3). The lowest was at Jadalet (9 ±3sd). At Ma Gyi, inshore sites had fewer fish than offshore sites (Figure 2.3). We found more fish at South Bird I in April than in December, but more fish at North Bird I in December than April.

The most common fish seen were snapper, parrot fish and butterfly fish, with low numbers of other groups (Table 2.1). Snapper were very variable in number, ranging from none to schools of 300.

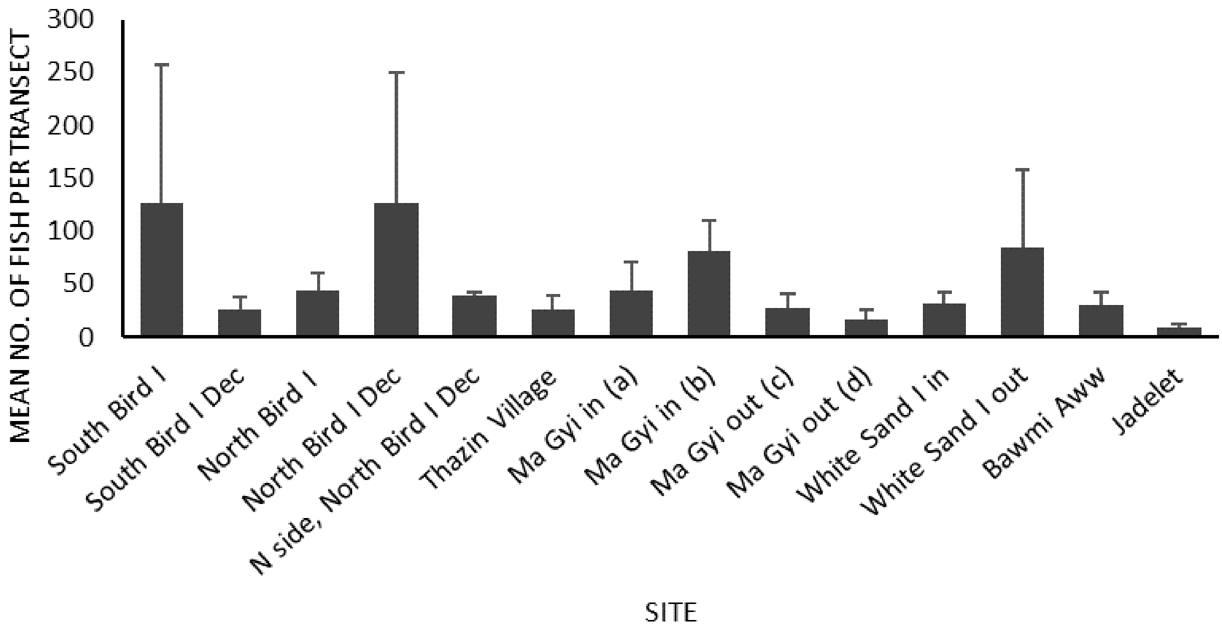


Figure 2.3: Mean number of fish per transect at 14 sites (± sd) on the Myanmar Mawtin coast. Each transect was 20 m in length, and 5 m wide by 5 m high. N=5 transects. Surveys conducted in April/May unless otherwise marked (December).

iii Invertebrate surveys

No banded coral shrimp, pencil urchins, crown-of-thorns or tritons were seen on or off transect at any site, with the single exception of a deep dive at Pyin Taung, one of the outer islands off Ngwe Saung, where a single crown-of-thorns was photographed in December (Figure 2.4a). This site was not surveyed for coral, as it was too deep. One collector urchin was seen at North Bird Island, Ngwe Saung, in April, which was also the only site where giant clams were seen (one on transect, several off transect). A number of empty clam shells were seen here as well. One single indicator species of holothurian was seen on one transect, at North Bird Island in December.

Lobsters were very scarce, and always very small. In total, only seven were seen on transects during the 14 surveys, and none were seen on transect in December. They were rarely seen off transect, either, except at the deep sites that were dived on the offshore islands around Ngwe Saung (not surveyed), where very small lobster were not uncommon (e.g. Figure 2.4b).

Numbers of needle-spined urchin, *Diadema* sp., varied greatly, from zero or one or two per transect, up to approximately 1000 (Figure 2.5). Note that such large numbers are impossible to count accurately along such a large transect and this is an estimate only). While the mean number of *Diadema* per each 100 m^2 transect area was 24 (±46sd) urchins in April/May, there were very large numbers of small urchins (up to 1000 per transect) found in December on the north side of North Bird Island. This pushed the overall mean number per transect for all surveys to 74 (±188sd) urchins.

Table 2.1: Mean numbers of Reef Check fish groups recorded per transect for each of 13 sites (N=5 by 20m transects, each 5 m wide by 5 m high; sd in brackets; BF=Butterflyfish; HA=Haemulidae; SN=Snapper; BP=Bumphead parrotfish; PF=Parrotfish; ME=Moray eel;

Site	BF	HA	SN	BP	PF	ME	GP
South Bird Is	14.0 (5.5)	1.8 (2.2)	102.0 (1.6)	0.0 (2.8)	7.6 (9.3)	0.2 (0.0)	0.8 (0.5)
South Bird Is Dec	7.2 (2.3)	0.2 (0.5)	2.8 (1.9)	1.0 (1.4)	13.2 (11.6)	0 (0)	1.4 (1.5)
North Bird Is	15.6 (4.9)	2.0 (1.8)	15.6 (124.2)	0.6 (0.0)	9.6 (8.4)	0.0 (0.4)	0.6 (1.3)
North Bird Is Dec	13.2 (5.4)	1 (1)	93 (121)	1 (1.4)	15 (9.4)	0 (0)	2.8 (1.8)
N side, North Bird Is Dec	12 (3.2)	0.8 (1.1)	8.2 (5.3)	2.4 (1.8)	12 (4.5)	0 (0)	3.2 (1.3)
Thazin Village	5.2 (1.8)	0.0 (0.0)	5.0 (5.4)	0.0 (0.0)	13.0 (9.7)	0.2 (0.4)	1.4 (1.3)
White Sand Is in	13.2 (2.4)	0.4 (0.0)	11.4 (5.7	1.6 (0.0)	15.2 (2.5)	0.0 (0.0)	1.8 (0.8)
White Sand Is out	21.6 (5.2)	0.4 (0.9)	23.6 (84.6)	1.8 (2.3)	33.2 (21.3)	0.0 (0.0)	1.0 (1.3)
Ma Gyi in (a)	6.4 (5.2)	0.0 (0.4)	15.0 (8.5)	0.0 (4.8)	3.8 (6.6)	0.0 (0.0)	1.6 (1.1)
Ma Gyi in (b)	8.0 (2.6)	0.0 (0.0)	4.8 (7.0)	0.0 (0.0)	1.8 (5.5)	0.0 (0.0)	1.2 (1.5)
Ma Gyi out (c)	13.6 (4.8)	0.2 (0.9)	7.4 (9.9)	2.6 (2.3)	6.0 (15.7)	0.0 (0.0)	1.4 (2.0)
Ma Gyi out (d)	12.8 (7.4)	0.4 (0.9)	50.8 (21.5)	1.6 (2.0)	18.2 (31.3)	0.0 (0.0)	0.6 (1.4)
Bawmi Aww	9.6 (1.7)	0.0 (0.0)	5.6 (3.1)	0.0 (0.0)	12.0 (2.2)	0.0 (0.0)	2.4 (0.9)
Jadelet	5.6 (3.3)	0.0 (0.0)	1.4 (7.2)	0.0 (0.0)	1.0 (3.2)	0.0 (0.0)	1.4 (1.1)

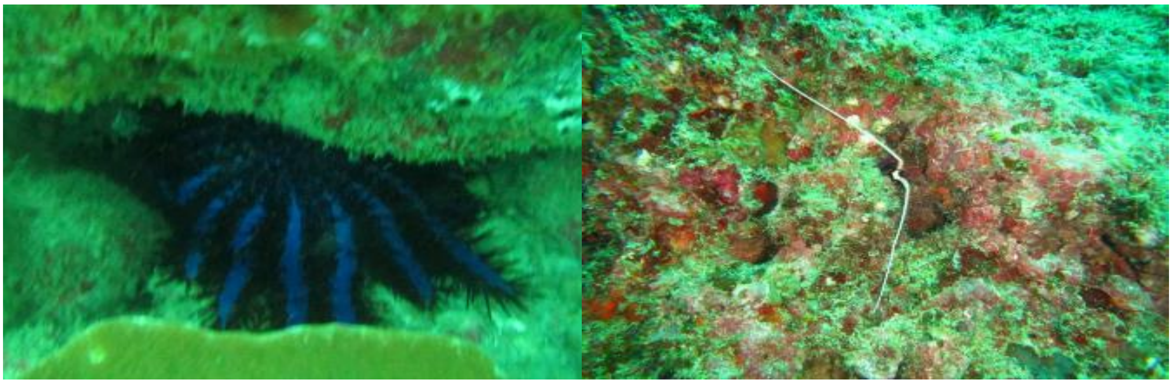


Figure 2.4: (a). Crown-of-Thorns starfish; and (b) small lobster. Pyin Taung, December 2016 (Photo a: Soe Tint Aung; b: Salai Mon Nyi Nyi Lin).

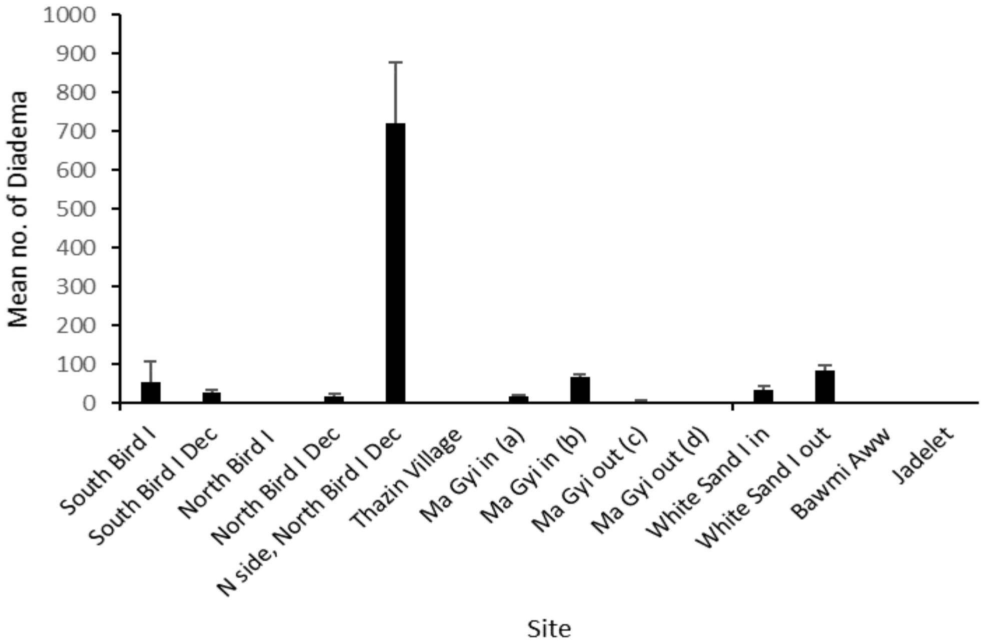


Figure 2.5: Mean number (±sd) of *Diadema* sp. found for replicate 5 by 20m Reef Check transects on the Myanmar Mawtin Coast in April and December 2016. Surveys were conducted in April unless otherwise specified (December). Arranged from south to north.

2.3.2 Resilience assessments: 2016 surveys

i Jadelet and Bawmi Aww (Magyizin)

Lying approximately 30km north of Shwethaungyan, this locality was identified by local fishermen as being a site of high coral diversity and cover. The first site (Jadalet) consists of coral communities on shallow rocky shelves that extend from an eroded headland. The second (Bawmi Aww) is separated from the first by several hundred metres of featureless sand, and is a community of corals atop a rock shelf that stands 1-2m proud of the seafloor in 15m of water. Both sites are heavily fished by the

locals (nets, hook and line and hookah); upwards of 20 mid-sized fishing boats were operating within the large bay on the day of the survey, several of which were hookah-equipped.

The coral community is much more diverse than at the sites further south and presents as a mixed community dominated by encrusting and submassive (mostly faviid) corals attached to rock spurs (Figure 2.6). Some carbonate platform accretion is evident, although not extensive. Broad rocky spurs are interspersed with wide sandy gullies. Coral cover on the ledges is relatively dense (40-80%), comprising mostly encrusting or submassive forms with numerous small table or robust branching *Acropora*. Damage and partial mortality of colonies was pervasive, attributable to fishing activity (there was an abundance of broken and discarded fishing gear, including many pieces of net entangled on corals). Occasional large colonies of *Porites* (cf *lutea*) occurred mainly on rocky ledges, rather than sand, although *Acropora* colonies occurred on both rock and sand. Growth anomalies were common on *Porites* colonies.

Disease (White syndrome) was present, but less than 5%, almost entirely on *Acropora*. Juvenile corals (approximately 50% *Acropora*, the remainder mostly faviid) were common. This site was probably the most diverse coral community observed during this survey.

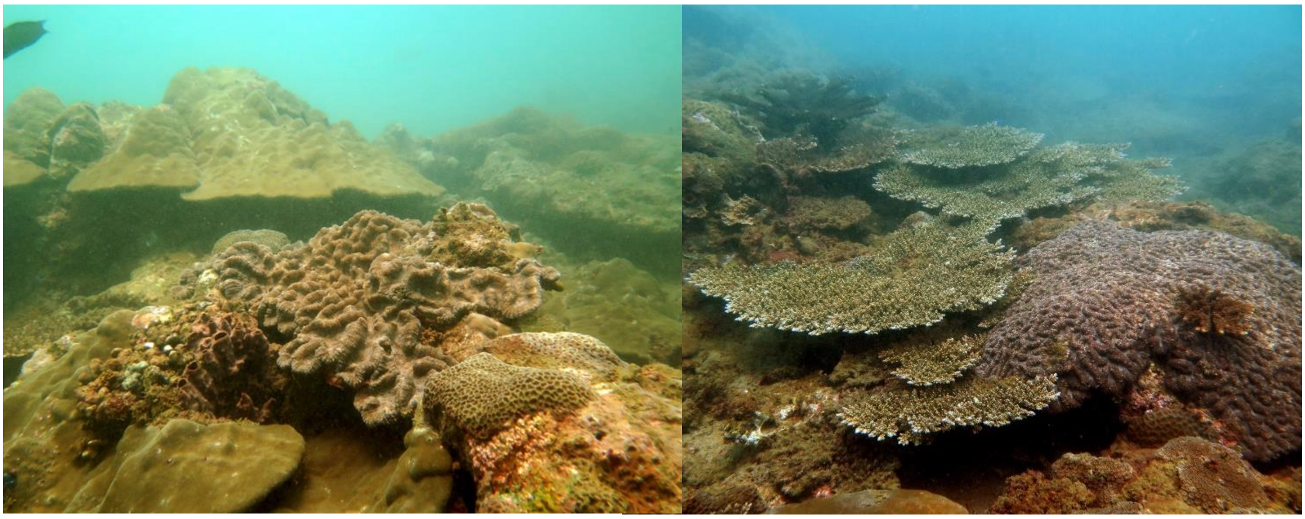


Figure 2.6: Coral Community at Jadalet (photos J. True).

Bawmi Aww is slightly shallower than the deepest part of Jadalet but is similarly composed. It lies atop a wide, low rock platform in 8-12m of water, and is apparently an easy target for fishers. Large massive and encrusting colonies dominated the landscape in the deeper areas. The shallowest area was a boulder community. The community is predominantly massive *Porites*, with *Diploastrea* relatively common, and many small corymbose and robust *Acropora* around large rocky boulders, albeit heavily impacted and suffering high levels of partial mortality and disease (Figure 2.7). Several species of soft corals (*Sarcphyton* and *Sinularia* spp) were apparent at the sandy margin of the main rock platform. Large sponges were common, but frequently damaged.

Fish numbers here were higher than at Chaung Tha, but less than at Ngwe Saung. Small schooling lutjanids and caesionids were encountered episodically. Occasional mixed schools of small scarids. labrids (especially *Thallasoma* sp), chaetodontids, and several species of pomacentrids were quite common. Mulliids, gobiids and saurids were common in the sandy areas between rock platforms, with saurids frequently being found on top of dead colonies. Small epinephiline serranids were rare in the rock platform communities; similarly for haemulids. Some serranids, haemulids and lethrinids were observed in the sandy area to seaward of the coral community, but table fish were very scarce in general.

Small lobsters (*Panulirus cf versi*color) were visible in horizontal cavities in the rocky communities further away from the shoreline (and hence away from the easiest sites for fishing). The area is clearly

very heavily fished; several boats were observed to be carrying hookah gear, and the area apparently obtains considerable income from seafood (especially table fish and crayfish); this intensity is reflected in the paucity of the fish community.

Bawmi Aww had larger numbers of small lutjanid fishes (especially small schooling species [cf *kasimira* and *indicus*]). Few commercial species were present at this site. Apart from sparse scarids, siganids and caesionids, few fish were apparent. The exception was saurids, and mullids, which were common on the sand around the coral community.

The coral communities at this site are fully exposed to the strong SW monsoon. The low profiles of the *Porites* and *Diploastrea* colonies suggests that wave action exerts an influence on community composition. The lack of coral on the sand at Bawmi Aww indicates that the rock ledges and boulders provide the only secure attachment for corals, which is likely a consequence of the monsoon storms excavating the sand. The wide bays north and south of these localities are both associated with large mangrove systems, which may also contribute significant freshwater plumes during the rainy season. Since coastal agriculture and development is sparse in this locality, terrigenous runoff does not appear to be a significant environmental control on the coral community. Sedimentation was negligible, although algal growth was prolific, suggesting that there is considerable influx of nutrients from the estuaries nearby.

Figure 2.7: (a) Coral community of Bawmi Aww; and (b) typical reef profile for the area. (Photo J. True)

Large amounts of broken and discarded fishing gear were evident at both sites. Fishing pressure is considerable, with all types of gear in use at both sites. Damage from anchors, fishing gear and aggressive hookah-hunting has caused a significant amount of physical damage to the coral community, and has probably decimated the fish community. The prevalence of coral disease may also be associated with the use of chemicals to capture lobsters. Local coastal development is minimal, so that runoff is not a factor in coral health. No marine activities other than fishing occur at these sites.

The lack of fishes in most guilds, and the presence of coral disease at >5% prevalence suggests that the sites are under some amount of stress. Heavy recent mortality means that the area is going to be some time recovering, despite the relatively large numbers of juvenile corals. The source of the mortality event could not be discovered, but ongoing disease could be as easily associated with the aftermath of a mass bleaching event as with contemporaneous stressors such as chemical fishing. The lack of stressors other than fishing pressure may indicate that the sites could recover quite rapidly in the absence of fishing.

ii Shwethaungyan

The area around the Ma Gyi Field Station is a rocky platform (Figure 2.8 a, b) supporting a robust, but low-diversity coral community attached to bedrock substrate, with no visible carbonate accretion. Coral communities were entirely associated with rock platforms in shallow water. Architecture of the rock platforms consisted of layered, highly eroded sedimentary rocks forming shallow ridge/canyon habitats. Many of the rock platforms are semi-exposed at low tide.

Communities were comprised predominantly of robust table *Acropora* with less-frequent robust digitate and branching *Acropora*, interspersed with encrusting or submassive faviids and occasional *Pocillopora cf verrucosa*, foliose *Montipora* sp and small *Turbinaria* sp (Figure 2.9). Frequent colonies of red algae were observed, with occasional patches of filamentous green algae; turf algae was ubiquitous, especially on the numerous recently dead coral colonies. Coral cover around the rock platforms ranged from 5-45%, with recently dead coral accounting for another 5-25% of the substrate.

White syndrome was present at all sites (5-20% prevalence), and many colonies exhibited partial mortality. Growth anomalies were common on *Porites*, and to a lesser extent on *Acropora*. No bleaching was observed, but several colonies appeared comparatively pale in colour. Sponges were often noted to be overgrowing live corals, but whether they were aggressively attacking the corals or exploiting areas of recent partial mortality was not apparent.

Figure 2.8: (a) Rock platforms near Ma Gyi Field station at Shwethaungyan, Myanmar; and (b) typical profile of coral community associated with rock platform. Corals were more numerous on the exposed seaward side than on the protected side.

Figure 2.9: Typical corals and coral disease (bottom right) at Ma Gyi, February 2016, Mawtin coast, Myanmar (photos J. True).

Fish numbers here were higher than at Chaung Tha, but less than those of Ngwe Saung. Predominantly, the fish community was comprised of schooling herbivores (mostly siganids, but many small scarids also). Mulliids, gobiids and saurids were common in the sandy areas between rock platforms. Small schooling lutjanids and caesionids were encountered episodically. Small epinephiline serranids were relatively common around the *Porites* bommies, but rare in the rock platform communities; similarly for haemulids. Pempherids and holocentrids were likewise encountered associated with overhangs of *Porites* bommies or deep crevices within the horizontal strata. The lack of predators meant that many otherwise cryptic species were up in the water column. Juvenile crayfish (*Panulirus cf versicolor*) were visible in horizontal erosion cavities in the rocky communities further away from the estuary (and presumed fishing pressure).

Communities were all shallow (<8m), and are likely to experience severe wave stress in the SW monsoon season. Although agricultural runoff is light, acceleration of coastal development (especially widespread clearing of coastal vegetation and paving associated with resort development) is likely to increase issues associated with freshwater plumes. Visibilty during dives was generally poor –seldom more than 4-5m. The increase in local population associated with the impending tourism enterprises will put pressure on the local system, since there is no municipal infrastructure to handle waste water treatment (and the shallow septic systems employed by small resorts tend to contaminate groundwater during monsoonal rains).

No legislative or local administrative rules apply to restrict activities. Fishing pressure does not appear to be extreme, however discarded fishing gear was ubiquitous at all sites (mainly fragments of monofilament gillnets). Low numbers of meso-predators and large scarids suggest that the local fishermen are quite efficient, especially given the use of hookah-equipped vessels. The rapid increase in tourism activity and infrastructure is likely to have affected water quality to some degree, but is likely to be a greater factor during seasonal flooding, as community waste water management appears rudimentary.

The presence of coral disease at >5% prevalence suggests that the sites are under some amount of stress. Heavy recent mortality means that the area is going to be some time recovering; relatively low

coral diversity means that the disease outbreak is poorly-contained. The source of the mortality event could not be discovered, but ongoing disease could be as easily associated with the aftermath of a mass bleaching event as with contemporaneous stressors. Both vertebrate and invertebrate herbivores were relatively plentiful. Small numbers of juvenile corals in different size classes suggest that the site receives annual replenishment, but it is so far not clear from whence the recruits come.

iii Chaung Tha

The study site was located north and south west of a small islet (Thel Phyu, or White Sand Island), upon which local authorities have erected a pagoda.

No reef accretion was apparent at most sites, although one site exhibited what appeared to be a thin skein of carbonate reef over bedrock. All other communities were composed of coral colonies attached directly to bedrock of easily-erodible mudstone along a series of ridges and canyons lying more-or-less east-west (Figure 2.10). The communities around the islet were generally dominated by table *Acropora* spp (mainly A. *cf hyacinthus/cf. clathrata*).

Figure 2.10: Typical spur formation at White Sand Island. Density of corals was higher at the western (slightly more exposed) end of the ridge.

Occasional robust digitate (predominantly humilis-group, mainly *A.humilis, A. gemmifera, A. samoensis*) and branching (*A. cf rudis*) corals were found on the upper regions of the ridges, along with small faviids (mainly *Favia* spp) and some mussiids (mainly *Symphyllia radians*) (Figure 2.11). Rarely, a colony of foliose *Montipora* sp., *Galaxea* sp or *Merulina* sp also occurred, often on the canyon walls.

Coral cover on the ridges to the south and east varied between 10-70% live coral cover, with recently dead corals comprising up to 50% of remaining substrate. A recent large mortality event has apparently killed up to 30% of adult colonies. Continuing mortality due to disease (predominantly

White Syndrome, but occasional patches of necrosis similar to *Atramentous* Necrosis were observed on *Acropora* and *Montipora* colonies) affected between 5% and 10% of colonies in different sites. The cause of the mortality event and disease outbreak were not obvious at time of survey.

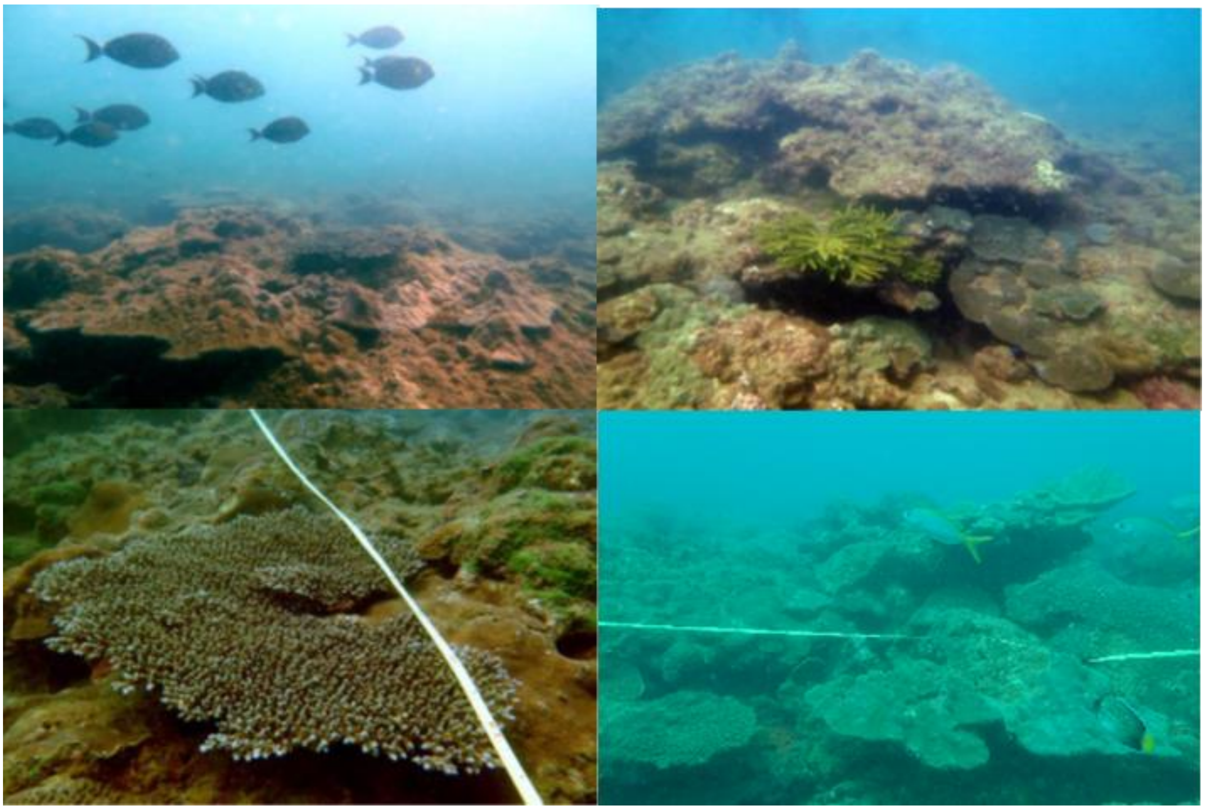


Figure 2.11: Typical corals at Chaung Tha, White Sand Island, Mawtin coast, Myanmar, February 2016 (photos 1-3, J. True, 4 SM-J).

The majority of fish sited during this survey were planktivores or herbivores. At the eastern sites of the island, although fish numbers were relatively high, the community was composed mostly of small pomacentrids, scarids, chaetodonts, caesionids and siganids. Occasional pomacanthids, acanthurids, nemipterids and (rarely) haemulids were sighted. Lutjanids and serranids were largely absent. Several saurids were almost always visible on top of dead coral colonies, especially at the bottoms of canyons or flats between ridges. Possibly because of the tourism activities, planktivorous pomacentrids (especially *Abudefduf bengalensis*) were plentiful in the upper water column. Small schools of pempherids were observable under overhangs. Small groups of schooling bannerfish (*Heniochus*) and chubbs (*Kyphosus*) were observed sporadically. Fish abundance was moderate, but skewed in towards small herbivores and planktivores. Mesopredators of any kind were rare, as were coral-obligate fishes such as anthine serranids. Small ornamentals were under-represented, but it was not clear whether this was a result of the coral mortality event or from collection by local fishermen.

Most of the coral communities at this site are semi-exposed to the strong SW monsoon. The communities are shallow, and comprised of species capable of resisting strong sheer stresses. The sites around WSI may be exposed to seasonal plumes from the estuary at Chaung Tha. The shallowness of the coral communities means they are likely to be vulnerable to freshwater plumes. As Chaung Tha is rapidly developed for tourism, the transport of nutrients from this source is likely to increase, and may exacerbate the observed disease outbreaks.

No legislative or local administrative rules apply to restrict activities on any of the islands. The offshore site experiences less visitation, simply because of distance, and the requirement for good weather. The ample supply of discarded fishing gear indicate that the local fishermen do not regard the tourism industry as a barrier to activity, and that the two industries are not partnering to mutual benefit.

The resilience of the system appears to depend on the level of anthropogenic activity, especially tourism and fishing. The presence of coral disease at >5% prevalence suggests that the sites are under some amount of stress. The source of the mortality event could not be discovered, but ongoing disease could be as easily associated with the aftermath of a mass bleaching event as with contemporaneous stressors. Numbers of ecosystem formers (mainly scarid and acanthurid fishes) are moderate, but not large. Turf algae covers much of the substrate, perhaps exaggerated by the proportion of recently dead corals, but only moderately controlled by the actions of herbivorous fishes. Invertebrate herbivores were not plentiful. Small numbers of juvenile corals in different size classes suggest that the site receives annual replenishment.

iv Ngwe Saung

Coral communities were reported around the Bird Islands lying approximately 11km offshore from Ngwe Saung. Tourism appears to be concentrated on the eastern side of the northern island, which harbours the richest marine community. Fishing in other places appears to be quite intense, suggesting that the tourism operators may have arranged some sort of informal sanctuary during the tourist season.

North Bird Island: The coral community on the eastern side is composed of individual colonies attached to bedrock substrate. No carbonate accretion was apparent. Large numbers of dead colonies indicates a relatively recent mortality event; however, there were no indications as to whether it may have been associated with 2015 world bleaching event, or from more proximal causes.

The hard coral component of the community is comprised of mostly table *Acropora* (cf A. hyacinthus), with frequent robust digitate colonies (almost entirely humilis-group species, especially *A. humilis, A. samoensis)* and very occasional robust branching coral (appears to be *A. rudis*). Massive *Porites* (mostly *P. lutea* with some P. densa and some *P. lobata*) (Figure 2.12). Occasional encrusting or submassive faviid corals (*Favia* spp and *Favites* sp) are present, as are (rarely) *Montipora* spp, *Goniopora* sp, *Symphyllia* sp and *Platygyra* sp. Colonial zoanthids were common. Coral cover averaged approximately 20-40%, occasionally up to 60%. Including the recently dead colonies, coral cover in recent years would likely have averaged >60%. Juvenile colonies were present, but uncommon.

On the northern side of the island, the coral community is sparse, with significant amounts of dead coral and physical damage (probably from anchors). The community was as above, albeit much reduced in apparent health. Coral cover was less than 10%, on average, occasionally 30%.

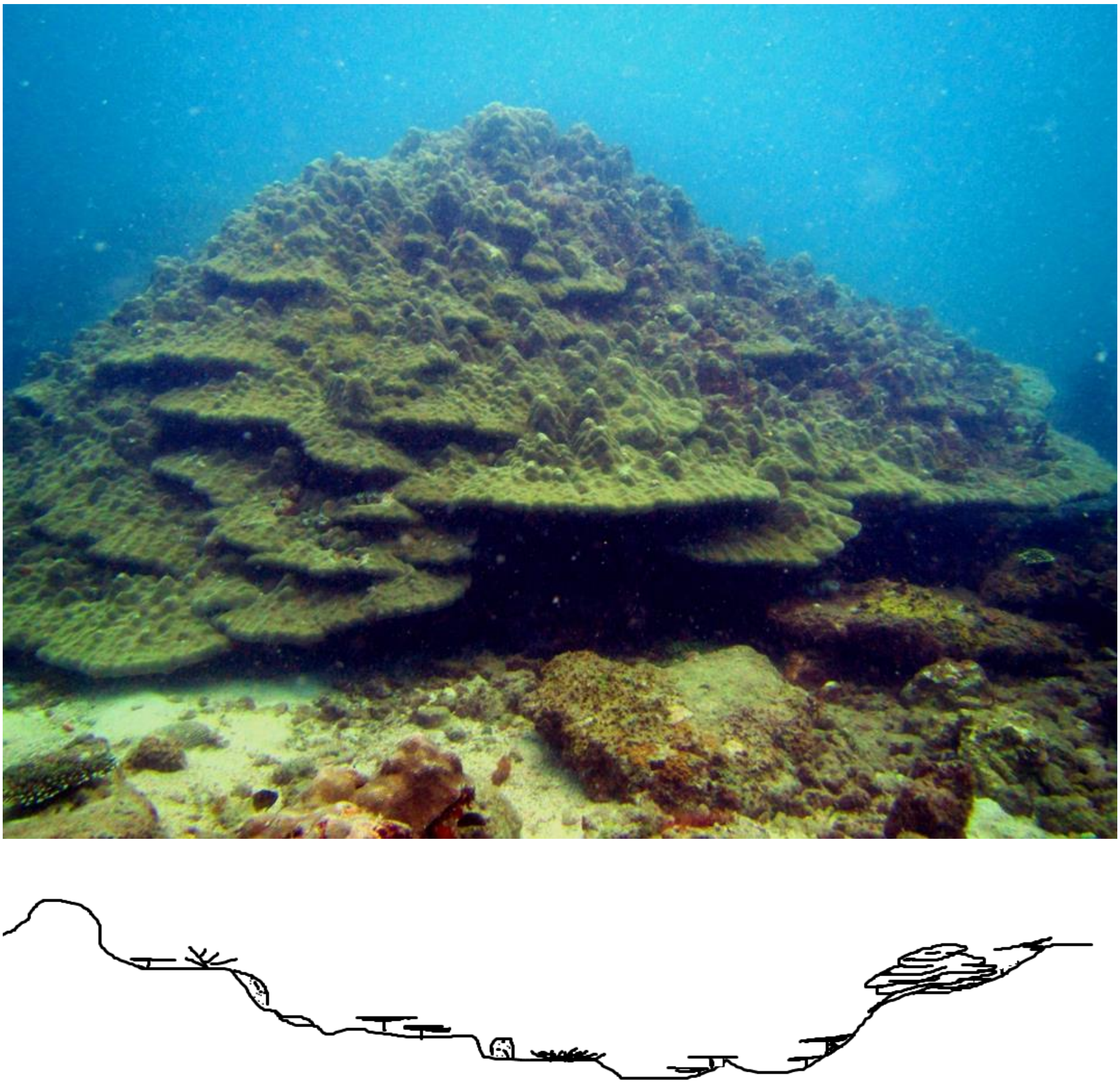


Figure 2.12: (a) Porites bommy, and (b) Typical reef profile of North Bird I.

South Bird Island: The southern island site resembled that of the northern island, but was severely degraded. Large numbers of dead coral colonies, with significant amounts of physical damage were observed. Community was similar to North Bird I, but much reduced in apparent health. Coral cover was less than 10%, on average, occasionally 20%. White syndrome and focal bleaching were observed on numerous colonies, as was partial mortality and algal overgrowth.

The majority of fish sited during this survey were planktivores or herbivores. At the eastern site of the northern island, although fish numbers were relatively high, the community was composed mostly of small pomacentrids, chaetodonts, caesionids and siganids. Occasional scarids, pomacanthids and (rarely) haemulids were sighted, but were wary. Lutjanids and serranids were largely absent. Several crayfish (*Panulirus cf versicolor*) were observed in rock crevices. The fish community of the northern side of the North Bird I, and that of South Bird I were much reduced; a number of pomacentrids, siganids and occasional pomacanthids and saurids.

All of the coral communities observed during this survey were relatively exposed to oceanic conditions. The SW monsoon blows strongly on this coast, and there are no significant barriers to

mitigate storm waves. The underlying substrate, an easily eroded mudstone, provides a poor foundation for reef accretion. All the islands should be far enough offshore to escape the majority of nutrification and sediment generation associated with the ongoing urban development at Ngwe Saung. Turbidity at the time of survey was moderate, albeit affected by stormy conditions in recent weeks, and it is likely that the waters around the islands are rich in plankton. Numbers of *Diadema* sea urchins were moderate; seaweeds were common in turf form, but macroalgae were rare.

All sites were affected by fishing activities, although the eastern side of the North Bird I less so than the other sites. This may have been associated with the more intensive focus on this site for tourism activities. At the time of survey, all tourism activity was boat-based, with parties of snorkelers transported from the mainland in relatively small vessels (capacity around 20), which appeared to be mostly converted fishing boat hulls. The lack of mooring facilities, however, meant that the vessels routinely anchored on top of the coral community, and inflicted considerable damage, since the vessels were heavy for their size (being converted fishing hulls), and used to anchoring in sloppy conditions, they used large anchors. The construction of the pier and facilities on the northern island may alleviate some of this anchor damage, but may also exacerbate it, as more boats are drawn to the more easily-accessible site. The presence of a dive tourism company in Ngwe Saung may provide a small counterbalance to mass snorkel-tourism and recreational fishing development, given appropriate encouragement.

Large amounts of broken and discarded fishing gear were evident at all sites, but particularly at the southern island, mostly monofilament gillnet fragments, with frequent fragments of monofilament fishing line. Rarely, larger nylon nets were found; these appeared to be resembled fragments of seine nets. Local boats appear to engage mainly in different types of net fishing, however several boats equipped with hookah gear were observed. The paucity of fishes which are normally poorly represented in net-based fisheries suggests that local fishers using hookahs are able to access and capture reef fish with considerable efficiency.

No legislative or local administrative rules apply to restrict activities on any of the islands. It appears that the local fishermen largely leave the eastern side of North Bird I alone out of consideration for the tourism operators, but this is likely to be a very informal arrangement between ex-fishermen. Its putative existence, however, demonstrates the efficacy of even a small amount of restraint on harvesting activities in this ecosystem.

The resilience of the system appears to depend on the level of anthropogenic activity, especially fishing. This is suggested by the strong differences between sites with and without tourism, which seems to act as a brake on fishing activity. Anchor damage and BDFG were ubiquitous amongst sites, and caused a general degradation of ecosystem health. The lack of ecosystem modifying fishes (principally scarids) means that available space is heavily overgrown by turf algae, potentially inhibiting coral recruitment. While small planktivores and herbivores were plentiful, the lack of fishes and invertebrates in key guilds suggests a lack of ecosystem redundancy, potentially increasing the locality's vulnerability to impacts. Large numbers of dead corals, and a high prevalence of disease suggest that the site has suffered a recent large impact, but do not give insight into the nature of the impact. Small numbers of juveniles in different size classes suggest that the site receives annual replenishment, but it is so far not clear from whence the recruits come.

Note that no crown of thorns starfish or corallivorous gastropods were documented any of the sites.

2.3.3 Resilience assessments: 2019 Surveys

i Shwethaungyan

The three sites at Shwethaungyan were all very different in character. The first (MG47, Figure 2.13) was the furthest inshore and was characterised by a series of shallow ridges, the sides and upper surfaces of which are colonies by a higher density of corals, especially tabulate *Acropora* and encrusting Faviidae. The channels between the ridges were covered predominantly by sand, and sessile benthic biota such as hard corals were sparse, with soft corals the most visible biota in these areas. The ridges were quite thickly colonised by hard corals, with obvious signs of having been

much more extensive in previous years, such as small, regular mounds of limestone along the ridges (recorded here as “rock”).

The second site (SFS1, Figure 2.13) was used as a training area during the previous FFI coral survey. The area is adjacent to a low, wave-swept rocky outcrop, and exhibited similar characteristics to MG47. The previous survey documented a severe disease outbreak at this site, and heavily eroded coralla were abundant around the site, and live corals less prevalent than recorded by the previous survey.

The third site (MG2, Figure 2.13), was the furthest offshore, and comprised a shallow area surrounded by rocky outcrops that serve as breakwaters against the waves from the west. The entire area encapsulated by the outcrops (approximately 10 hectares) comprised the largest single coral community recorded during these surveys, and represents a rich shallow water coral community. This site, too, showed clear signs of historical coral loss and appears to have been heavily impacted by a mortality event in the recent past.

Figure 2.13: Survey sites for 2019 resilience assessment at Shwethaungyan. Red star marks Pathein University Field Station at Ma Gyi.

Typical coral communities are shown in Figure 2.14. There was no simple relationship between distance from shore and health or abundance of the coral community; while MG2 (furthest offshore) exhibited highest live coral cover (Figure 2.15, 2.16), it was not greatly different in either abundance or composition from the most inshore site (MG47). It is noteworthy, however, that the mortality event was not accompanied by a phase shift to an algal-dominated system. Herbivorous fishes were relatively abundant at all sites.

Figure 2.14: Typical coral communities, Shwethaungyan. Photos J. True.

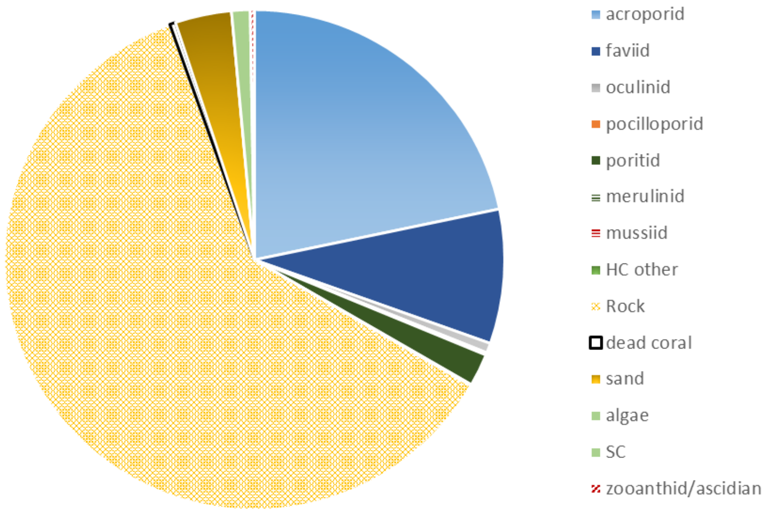


Figure 2.15: Benthic cover by site (%), Shwethaungyan.

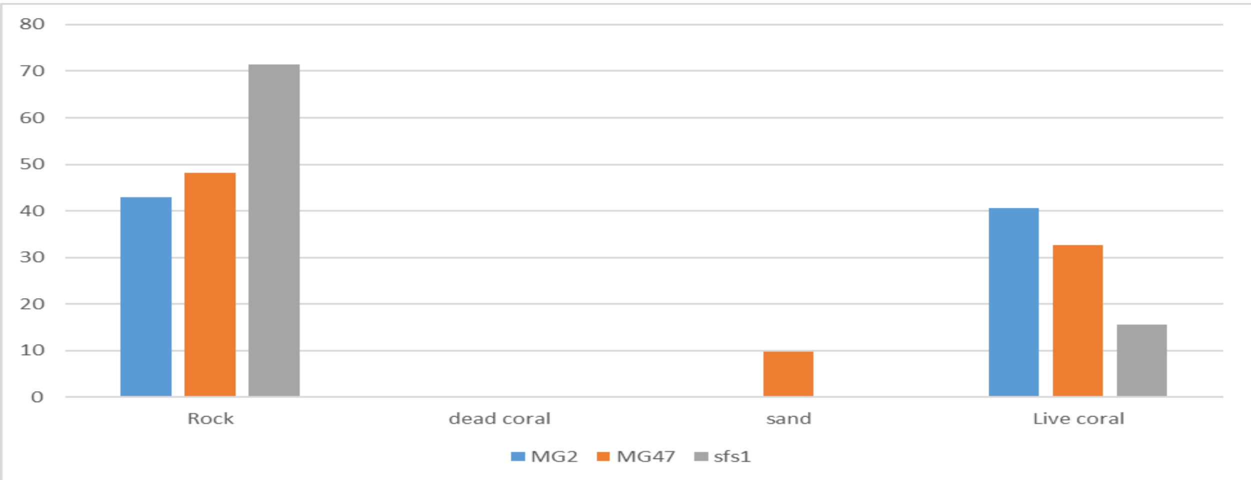


Figure 2.16: Mean cover per transect (%), Shwethaungyan.

The *Acropora* corals were mainly found amongst three morphotypes: the tabulate corals (3 species), corymbose/digitate corals (3 species), and robust branching corals (2 species). Rarer finds of caespitose colony growth forms (2 species) were mainly in the offshore site. Faviid corals were mainly of the encrusting, or submassive growth form, rarely massive. Algae appeared mainly in the form of a filamentous rhodophyte, and *Padina* sp. Soft coral at these sites was entirely composed of *Sarcophyton* sp.

All sites exhibited disproportionately large numbers of small colonies, compared with other locations (Figure 2.17, 2.18). This indicates that some degree of recovery from the recent mortality event is underway.

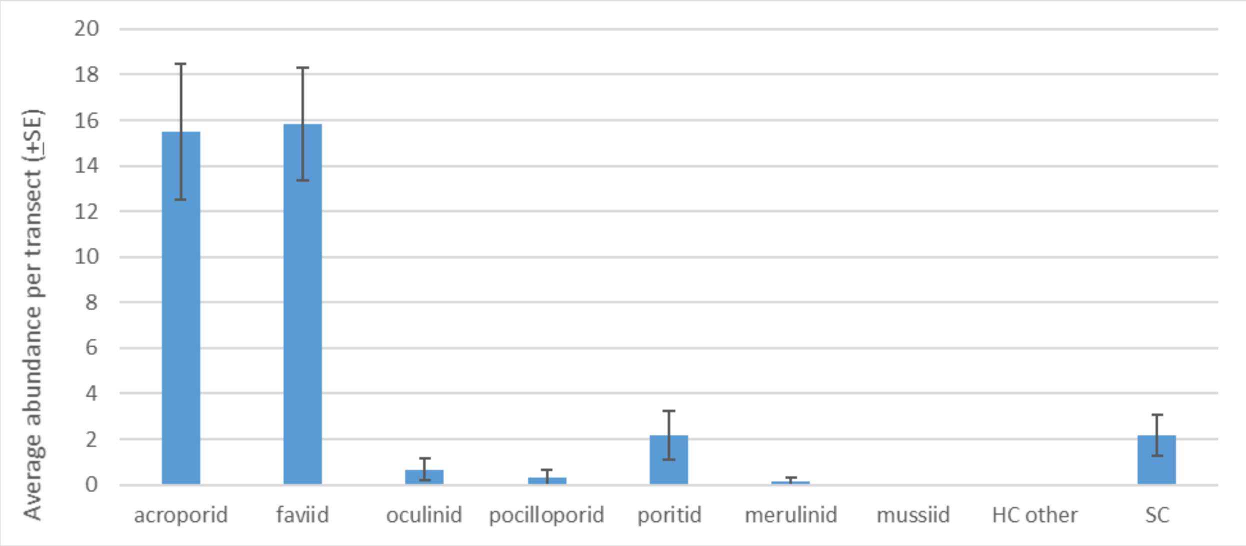


Figure 2.17: Colony abundance per transect, Shwethaungyan.

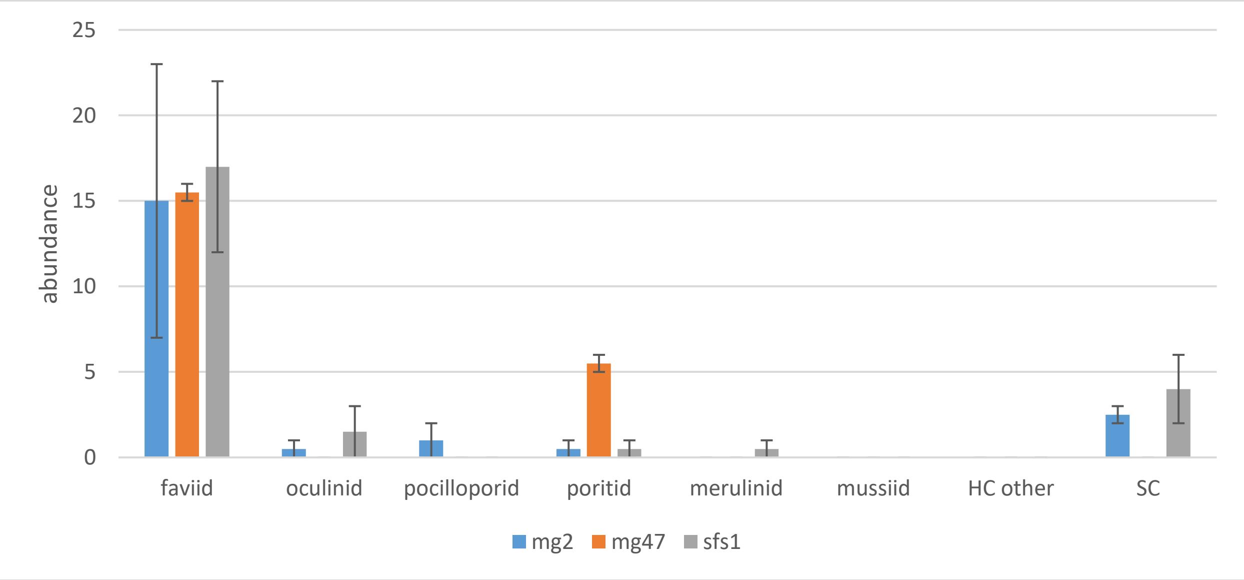


Figure 2.18: Colony abundance by site, Shwethaungyan.

The inshore sites exhibited greater size variability amongst corals than the offshore site, as well as a greater abundance of soft corals, perhaps reflecting a difference in water quality over even short distances.

ii Chaung Tha

The area around White Sand Island comprises a series of shallow ridges, the sides and upper surfaces of which are colonies by a consistently high density of corals, especially tabulate *Acropora* and encrusting Faviidae (Figure 2.19). Some disease amongst living coral colonies hints at the cause of the occasional dead colony, however the high proportion of dead and diseased corals recorded in 2016 were absent (likely broken off in monsoonal storms after extensive bioerosion by the many sea urchins present at the site weakened the corallum pedestal).

Figure 2.19: Typical coral communities, White Sand I, Chaung Tha.

The channels between the ridges were covered predominantly by sand, and sessile benthic biota such as hard corals were extremely sparse. The ridges were thickly colonised. The high variability in poritids in the transect data was a reflection of the presence of several large (>3m) colonies. Communities were heavily dominated by acroporids and faviids, although community diversity was high across families (Figure 2.20).

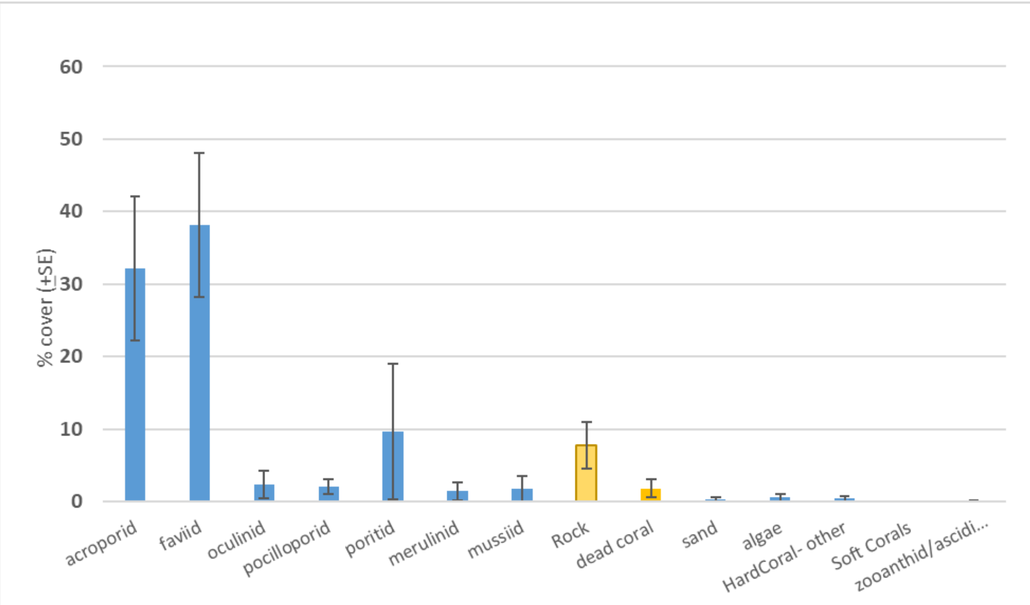


Figure 2.20: Mean % cover per transect, Chaung Tha.

iii Ngwe Saung

<u>North Bird I:</u> The first site at North Bird I was positioned on the shallow rocky shelf extending to the north of the island. This site is extremely exposed to weather and sea conditions, especially monsoon storms. Strong tidal currents sweep this site, and wave-surge creates turbulent conditions and severe shear-stress for benthic organisms.

The second site, on the sheltered eastern side of the island, comprises a shallow rocky shelf which drops away rapidly to a sandy bottom in about 20m. This site hosted perhaps the densest aggregation of hard corals documented on the west coast of Myanmar (Figure 2.21Figure 2.22). Although the area is small (<2 hectares), it provides insights into the protean state of the Mawtin coast coral ecosystems. This site, also, is the only locality within this survey to possess any degree of carbonate platform development (true "coral reef").

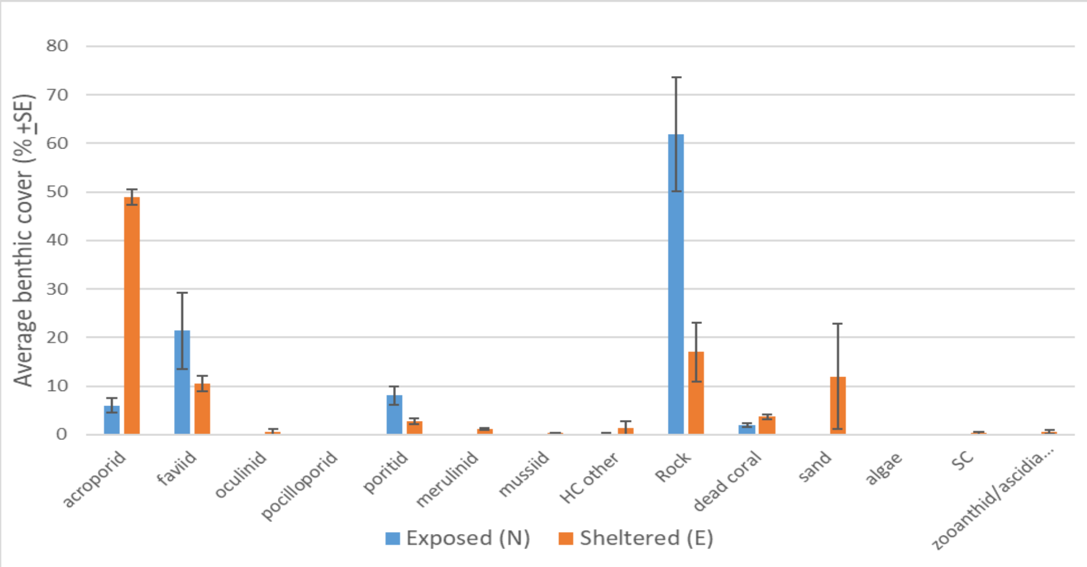


Figure 2.21: Mean % cover per transect, North Bird I.

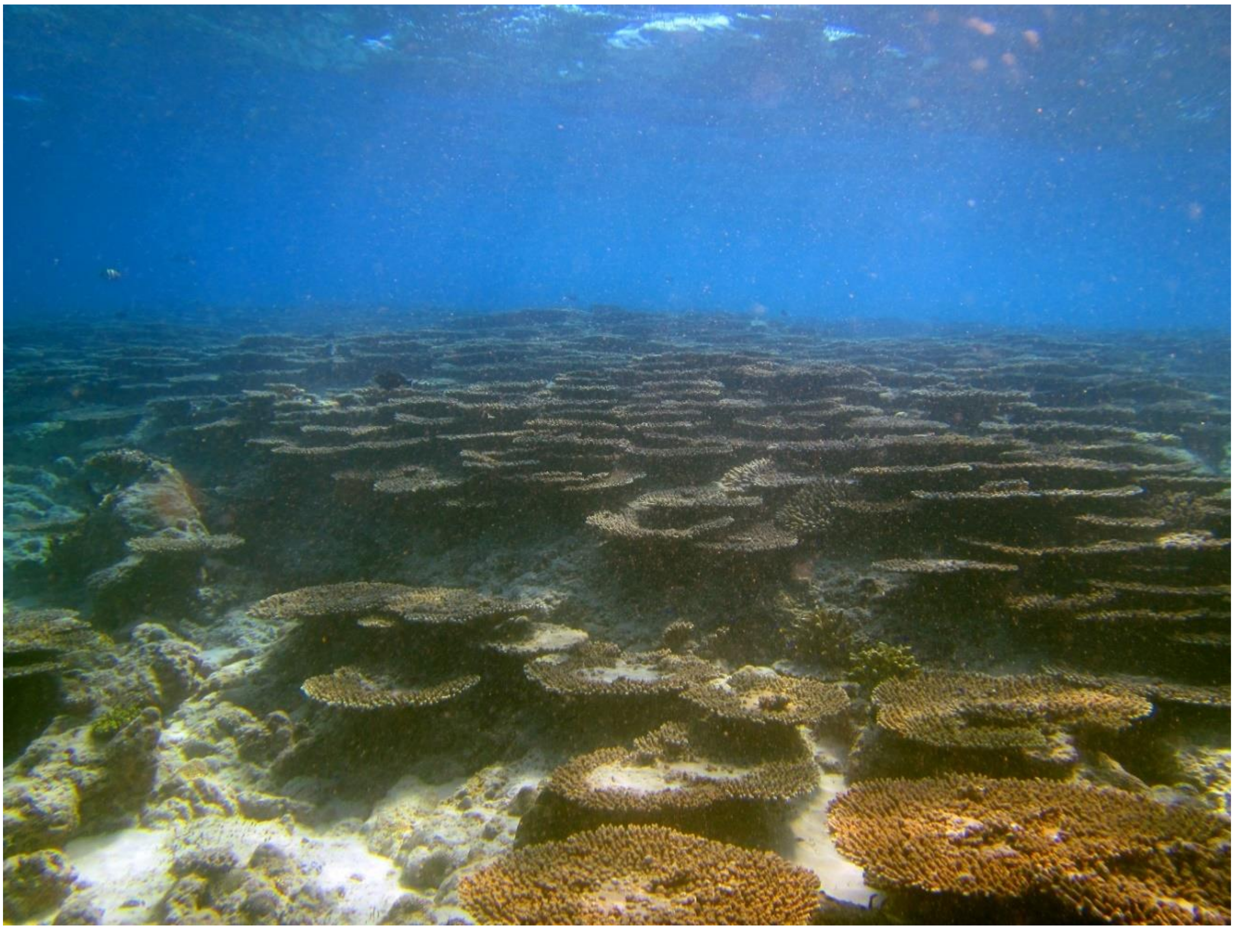


Figure 2.22: Eastern side of North Bird I.

The site was strongly dominated by *Acropora* corals, mainly of tabulate and robust branching morphologies. Encrusting *Montipora* were also significant contributors to coral cover. A diverse array of faviid corals, including some quite large (>1m) *Diploastrea* dominated the remainder of the assemblage. Most colonies were small (Figure 2.23). Numerous overturned colonies, and examples of partial mortality indicate that both storm damage and anchor damage take their toll on this community; it is likely that breakage from poorly-considered anchoring procedures (Figure 2.24) and the local boatmen's compulsion to anchor too short are more immediate threats to coral integrity than monsoon storms.

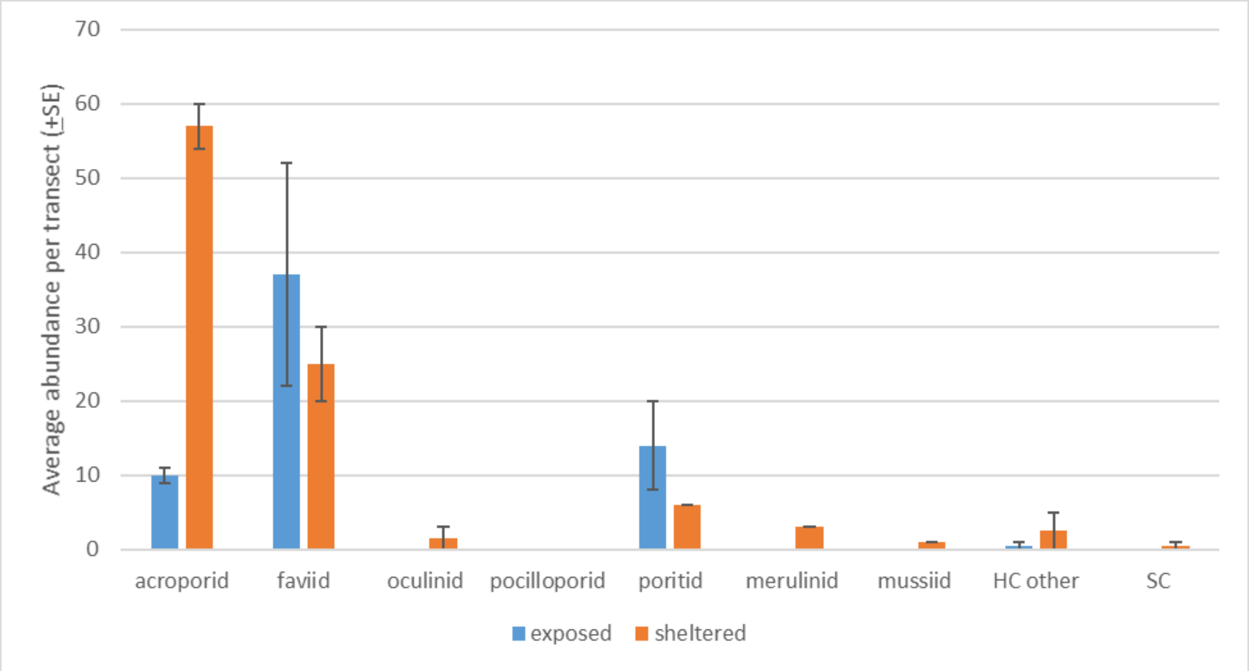


Figure 2.23: Mean colony abundance per transect, North Bird I.

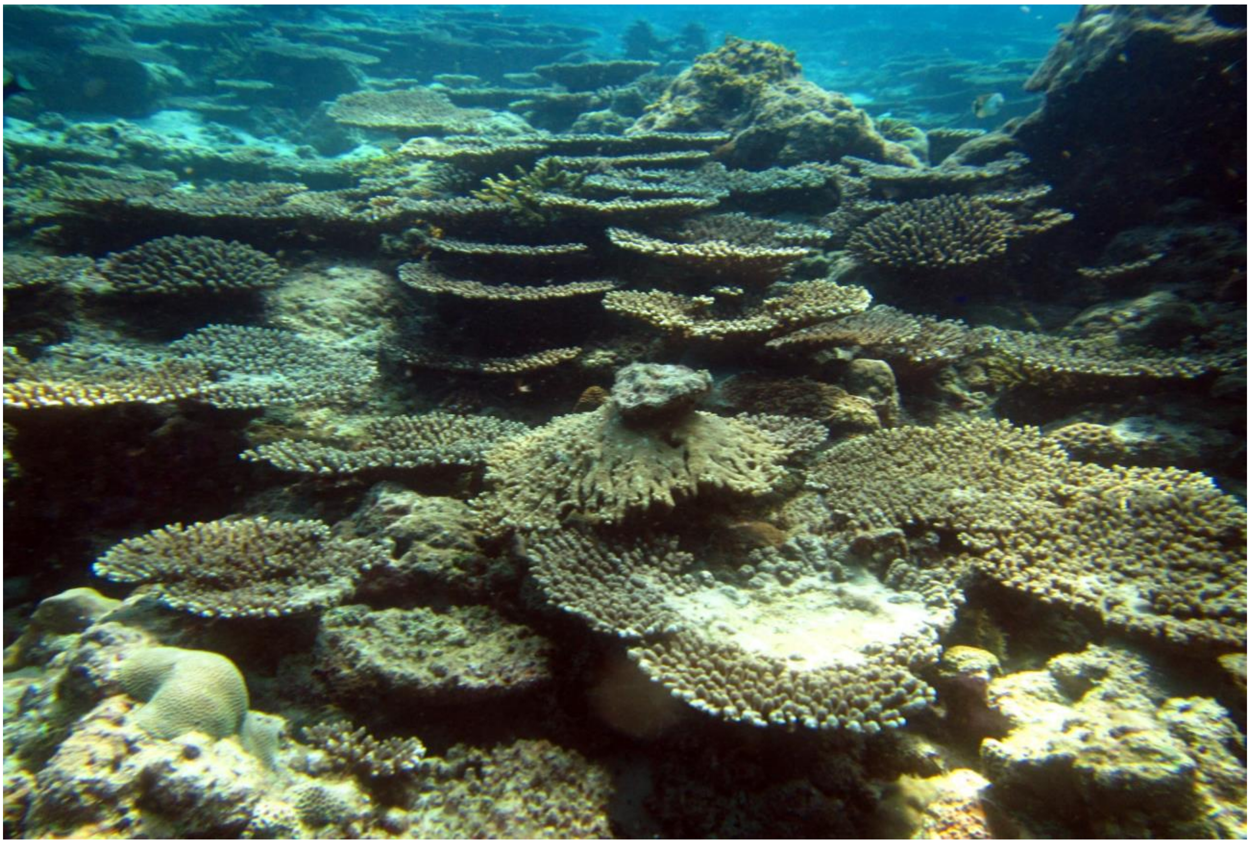


Figure 2.24: Coral showing anchor damage, North Bird I.

South Bird I: The first site at South Bird I was a deep community (>17m) dominated by corals on the southwestern corner of the main island (Figure 2.25). The site is exposed to monsoon storms, but is deep enough that only the most severe will affect benthic organisms. The second site was adjacent to the larger of the detached islets to the north east of the main island.

Figure 2.25: Typical deep water communities, South Bird I.

Coral cover was not high at South Bird I, and was similar for both the shallower and deeper site (Figure 2.26).

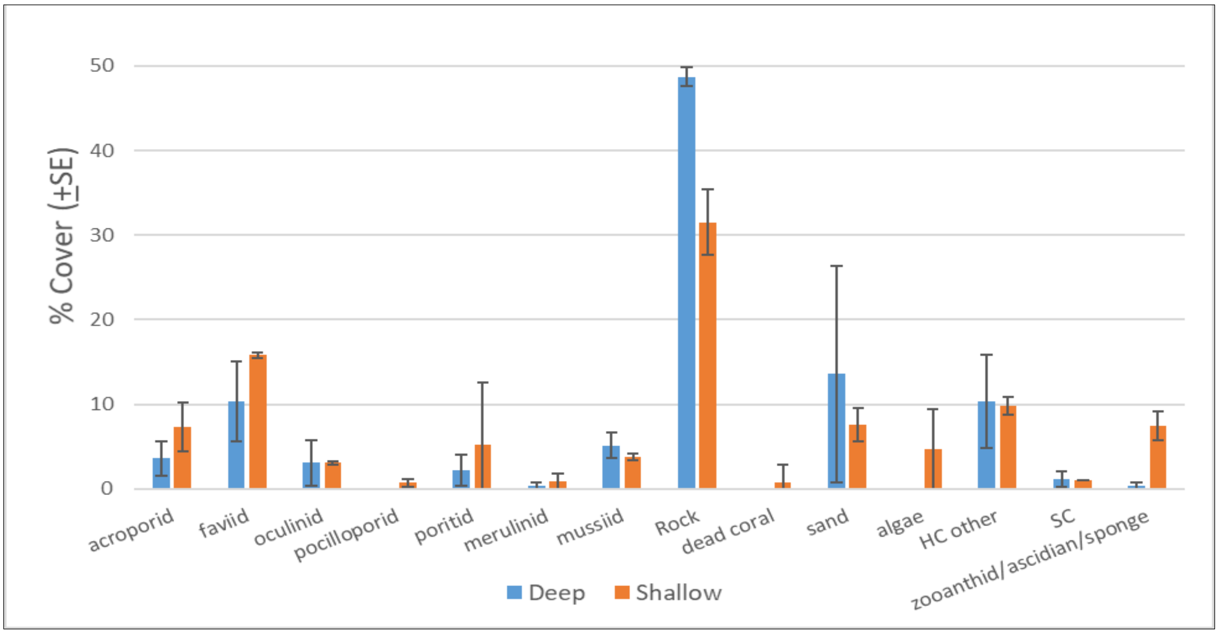


Figure 2.26: Mean % benthic cover, South Bird I.

Outer Islands (North West Group): A series of rocky pinnacles emerging up to nearly 40m from sea level, these rocks are surrounded by deep (30-50m) drop offs. Few sites in this group are amenable to survey because of turbulence and surf caused by tidal currents and oceanic swells. A surprising number of small, encrusting corals exist here.

The site was characteristic of offshore pinnacles, albeit depauperate in soft corals (Figure 2.27). Strong waves and currents over a metamorphic substrate predicate a dominance of encrusting and submassive forms (Figure 2.28). Numerous small colonies, rather than a few large colonies covered a surprisingly high proportion of available substrate (Figure 2.29).

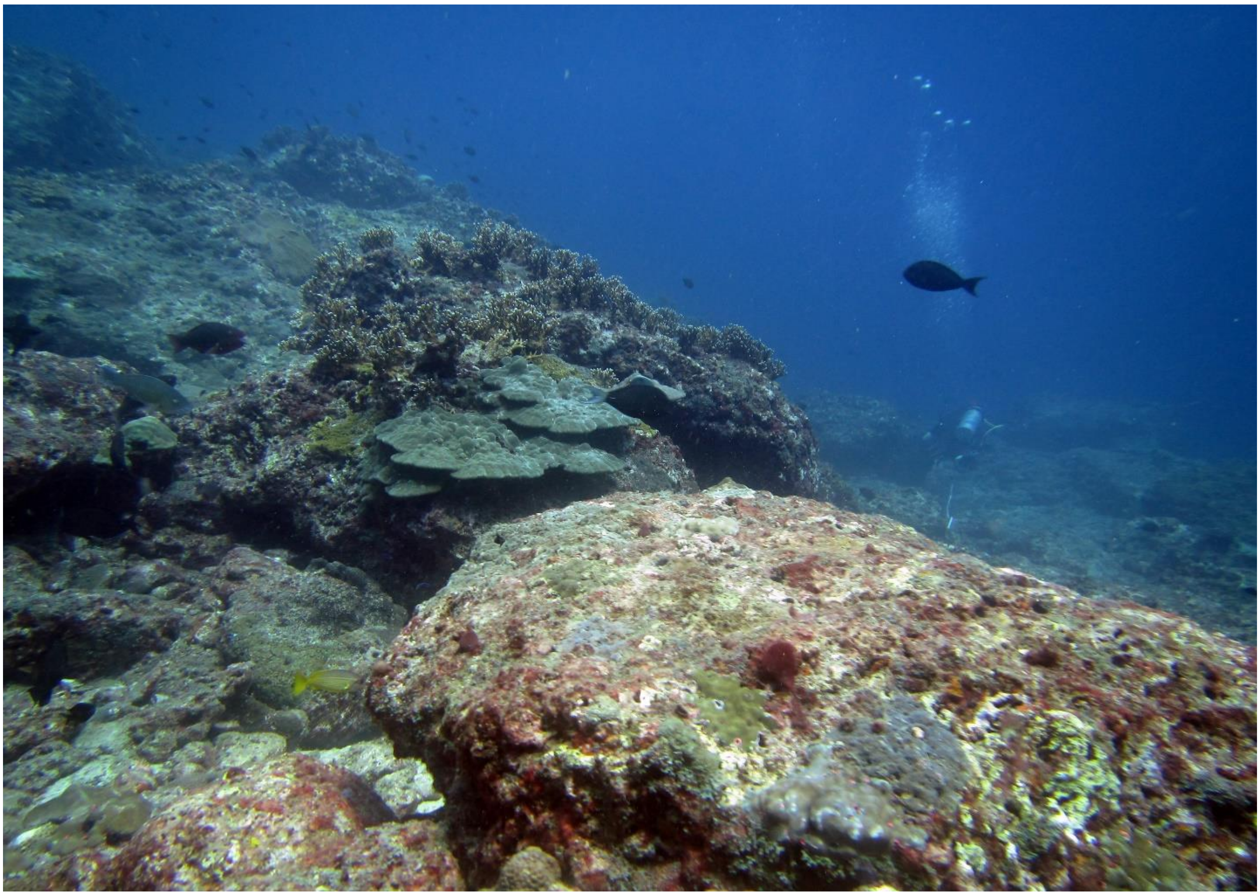


Figure 2.27: Typical underwater community, Outer Bird Is.

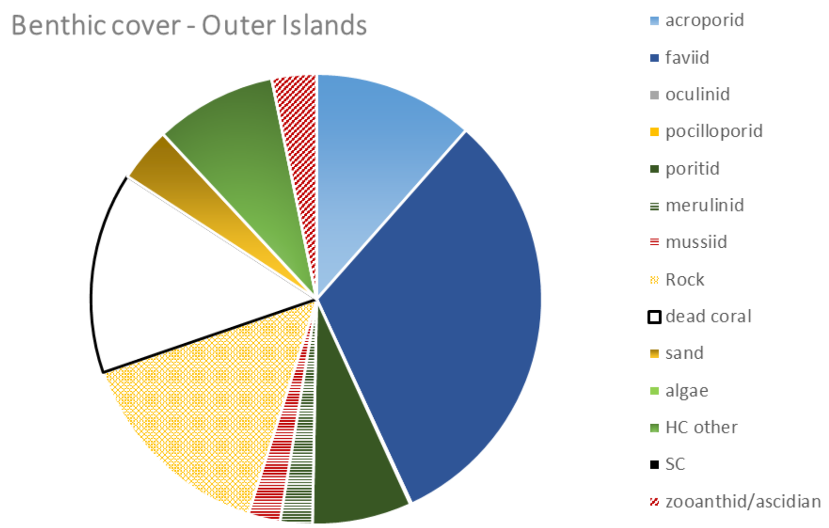


Figure 2.28: Benthic % cover, Outer Bird is.

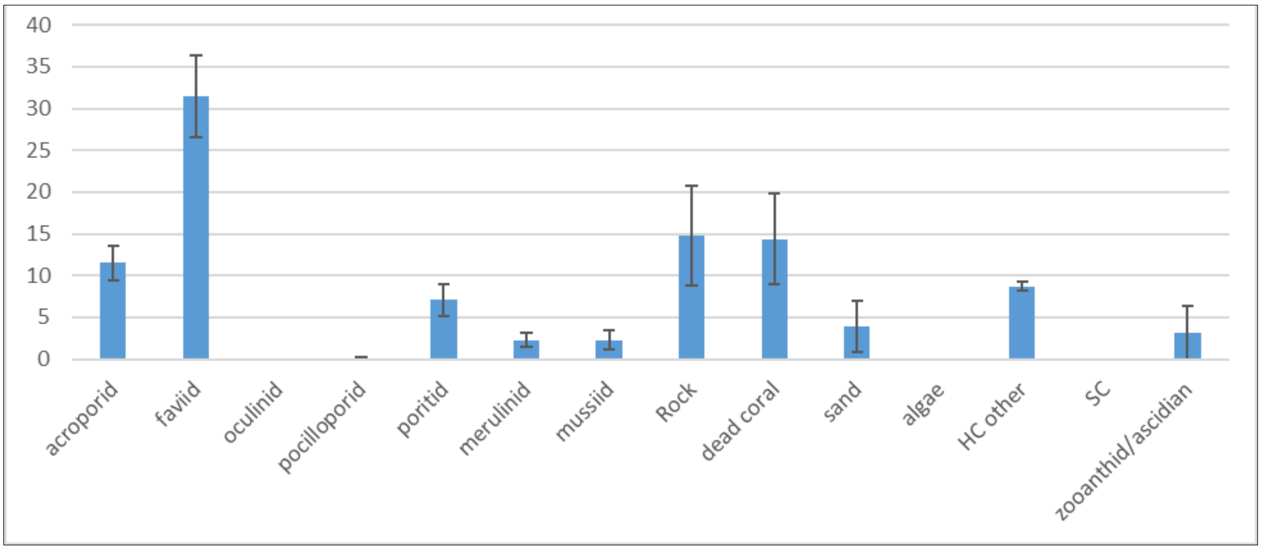


Figure 2.29: Mean colony abundance per transect, Outer Bird Is.

This was the only site where Millepora was the predominant structural benthos; it occurred on the more exposed boulders (Figure 2.30). The majority of scleractinian corals occurred either as encrusting, decumbent or submassive forms.

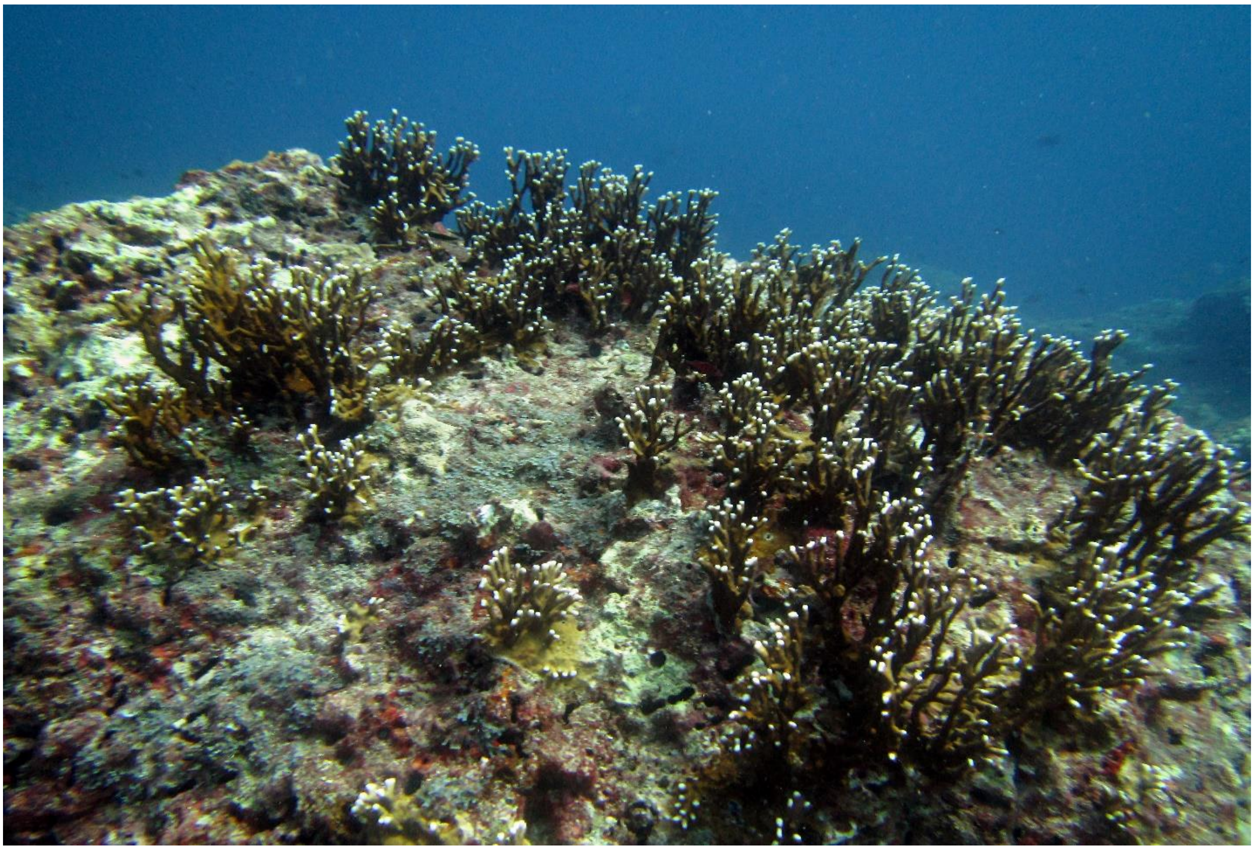


Figure 2.30: Underwater community, Outer Bird Is showing *Millepora* sp.

iv Resilience

Simple metrics reflecting stress on the coral communities are employed to provide rough indication of resilience and potential threats to the well-being of the coral communities. In particular, since no evidence of coral bleaching was observed during the 2019 survey, three proxies of community health are analysed: 1) the presence of juvenile corals, which indicates that there is potential for recovery; 2) the presence of coral diseases, which indicate that the community is under stress from environmental or anthropogenic pollution; 3) partial mortality of colonies, which indicates that the colony has either survived a stress event, with some loss of tissue, and is in the process of recovery, or that physical damage has occurred. Broken and discarded fishing gear (BDFG) is often implicated in both disease and partial mortality events, but is not necessarily an indication that a site is actively fished.

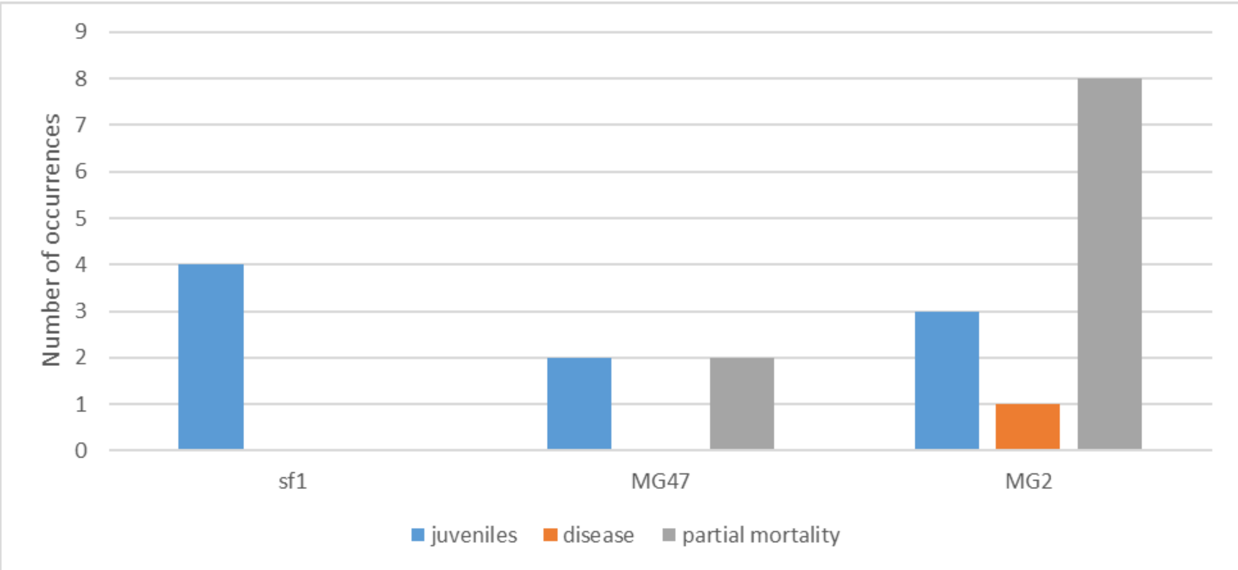


Figure 2.31: Resilience factors at Shwethaungyan.

These data should be interpreted in the context of community composition data; while all sites at Shwethaungyan apparently received juvenile corals, only the more offshore sites exhibited disease and partial mortality (Figure 2.31).

It should be noted, however, that the site SFS1 was recorded in a 2014 survey as experiencing severe disease outbreak, and exhibited the lowest coral cover (~15%) of all sites, suggesting that vulnerable corals have already died, rather than suffer partial mortality. It may be that the surviving corals are either far enough apart to confer some degree of isolation from infected colonies, or have some degree of immunity not ubiquitous in the larger community.

The offshore site in this case (MG2) exhibits considerable partial mortality, as well as some active disease (which may be responsible for the partial mortality numbers). Prolonged exposure to the active pathogen may have allowed development of an immune response across the community; perhaps also, the disease which was extremely active in 2014 might be less virulent in a better flushed environment that is generally less stressful to the coral community.

The lack of juvenile corals at Chaung Tha is worrisome from a resilience standpoint, and indicates a potential threat to the integrity of the community. Partial mortality appeared to be associated mainly with fishing activity and boat anchors (Figure 2.32).

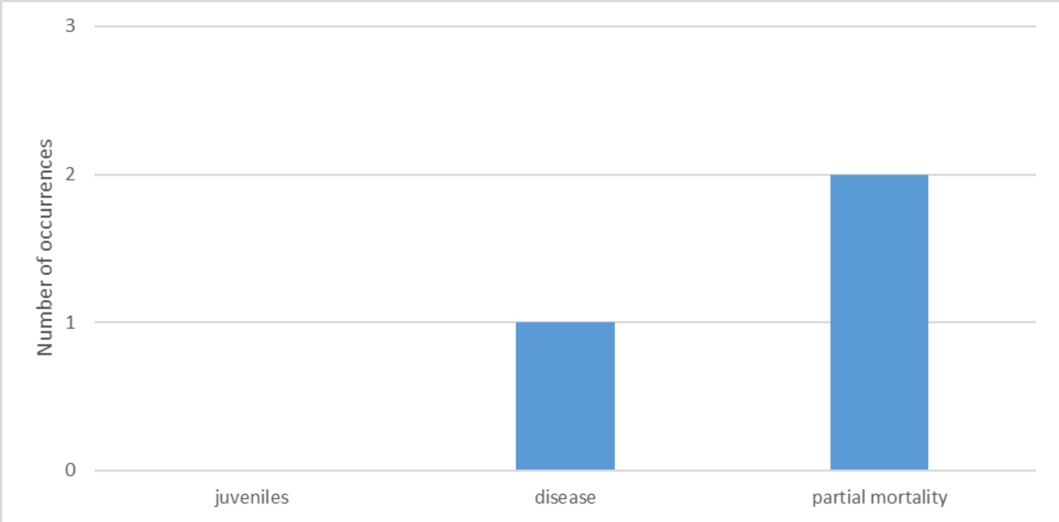


Figure 2.32: Resilience factors, Chaung Tha.

While some disease was observed at North Bird I sheltered site, the vast majority of the partial mortality observed at this site appears to be associated with broken or discarded fishing gear and anchor damage Figure 2.33). Prevalence of fishing gear was high (more than 9 nets or fishing lines /100m2), and obvious lesions associated with entanglement were visible. Net entanglement and physical damage to coral was especially prevalent in the exposed site, where strong waves and currents apparently exacerbate net breakage. Breakage, where part of the colony is lost, is not recorded as partial mortality; the effect is the same, however. Physical damage from anchor scraping or abrasion by ropes and nets accounts for considerable partial mortality.

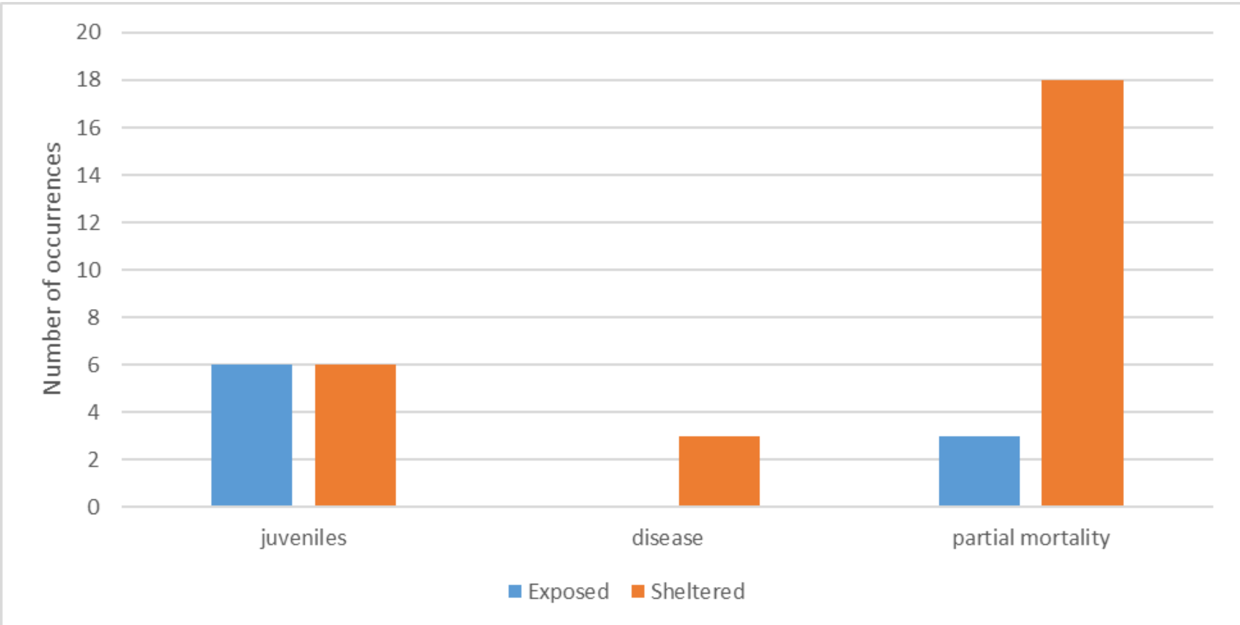


Figure 2.33: Resilience factors, North Bird I.

The deep site at South Bird I exhibited none of the factors along the transect line, however even expanding the search area either side of the transect revealed few instances of either juvenile replenishment of the community or partial mortality (Figure 2.34).

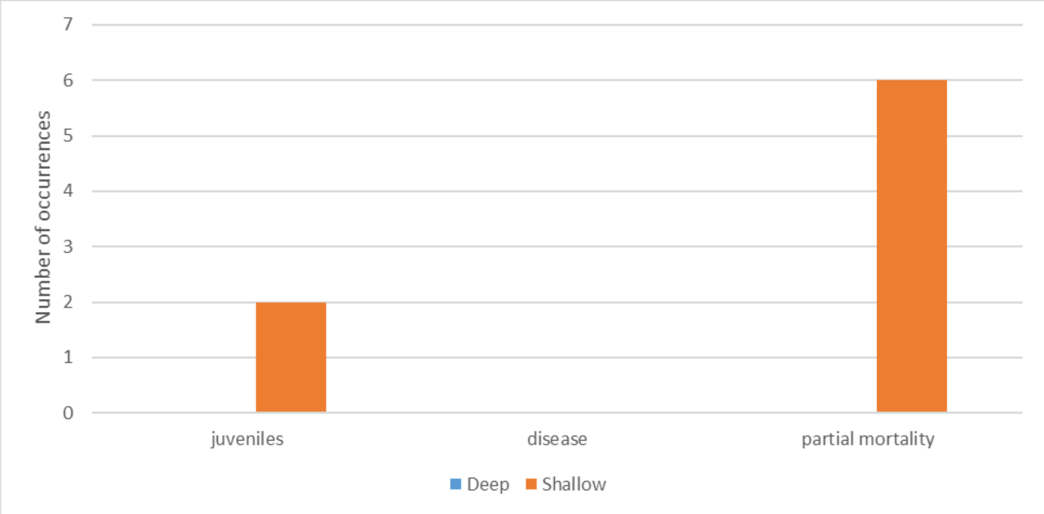


Figure 2.34: Resilience factors, South Bird I.

2.4 Discussion

2.4.1 Reef Check

The reefs of the Mawtin Coast of Myanmar are not true coral reefs, but rather rocky reefs with some coral. Coral cover varied from 2% to 60% at a transect level, and was very patchy. This was likely to be due a combination of factors, particularly poor visibility.

Coral cover was relatively high at South Bird I (39% ± 9sd) in the first set of surveys in May but only 9% (± 6sd) in December. Given the December survey at South Bird I was only around 130 meters further offshore (due to some heavy swell) than the survey in May, such a large difference is surprising, and demonstrates the patchiness of the reefs here.

It is noticeable that the four best sites in terms of coral cover (Jadalet, Bawmi Aww, North and South Bird Is) were also the deepest sites surveyed (8, 6, 8 and 7m respectively). All of these sites are further offshore than the other sites (see map, Figure 2.1) and turbidity was generally lower. In other areas, the distribution and abundance of coral is likely to be constrained by poor water clarity.

We found a mean hard coral cover of 41% (± 2se) across the 11 sites on the Mawtin Coast for the April/May surveys. This is less than the mean of 51% (± 3se) recorded by Howard *et al.* in 2014 for 115 Reef Check dives on the Tanitharyi coast (however note that when the authors included estimates taken by snorkelers, the mean cover was less). This is considered within the average range of 26-50% (Habibi *et al.* 2007), and is comparable to Reef Check data from other South-East Asian countries, which all had average coral cover, including Indonesia (Habibi *et al.* 2007), Australia (Bauer 2013), and Malaysia (Yewdall 2013).

Rock was nearly as abundant on the Mawtin coast as coral (mean 40% ± 2se), whereas the Tanintharyi coast had very little rock (<5%), with more dead coral and coral rubble (Howard *et al.* 2014). This difference is explained by the fact that the reefs of Tanintharyi are generally true coral reefs, built of limestone, not rocky reefs covered with some coral.

The mean number of *Diadema* per transect on the Mawtin surveys was 74 (±188sd) urchins. There was high variability between sites and within transects. Many sites had a lot of empty holes which looked as if urchins had been present recently. Most urchins seen were small, and on one transect, a large and recent recruitment event appeared to have happened, with several hundred urchins around 5-10 mm in diameter observed within a single 10m^2 area (South Bird Island, pers. obs. SMJ). Very large numbers were found at North Bird I in December. A mean of 56 (± 11se) were observed per transect in the Tanintharyi in 2014 (Howard *et al.* 2014). Mean numbers across South East Asia are reported as being 27.26 per 100m^2 transect (Chelliah *et al.* 2012), with very high variability (shown as error bars, not specified whether standard errors or deviations).

In a healthy reef system, urchins, in combination with herbivorous fish, control algal growth and keep substrate clear for settlement by colonial invertebrates. Where urchins are not present, coral cover tends to be low and algal biomass high (Furman & Heck, 2009). High or increasing numbers of *Diadema* are often taken to indicate above normal levels of nutrients; however, higher numbers were observed for the more offshore sites, making it unlikely to be a nutrient issue. On overfished coral reefs, urchin densities have often been found to be high (e.g. Hay, 1984; McClanahan *et al.* 1996), but in this study, some reefs with more fish had higher numbers of urchins. The pattern of fish densities on offshore compared to inshore reefs in the Mawtin coast, and any correlation with urchin densities, warrants further analysis but is outside the scope of this report.

Numbers of fish were highly variable. Butterflyfish, snapper, parrotfish and grouper were seen at all sites. Most sites had low numbers of fish, with the higher numbers generally driven by one or two transects with larger numbers of fish e.g. Outside White Sand I had 76 parrotfish on one transect, while at South Bird I up to 300 snapper were seen on a single transect in April, and similar numbers at North Bird I in December on two transects. Hence, while we found more fish at South Bird I in April compared to December, and more at North Bird I in December than April, these differences were driven by some very large schools of snapper passing across the transects.

South Bird I in May and North Bird I in December had the highest fish counts. This may be because they are the furthest offshore and most distant from anchorage sites i.e. less fishing pressure. There are no wharves or infrastructure on the open coast, and boats putting out from Ngwe Saung are kept in the tidal river. Larger fishing boats can only access the coast when tides are high enough to get boats in and out. However, both Bird Islands showed evidence of high fishing effort, with North Bird I in April having the highest proportion of net fragments. As the coral at these sites was in good condition, relatively intact, and more branching than at other sites (pers. obs. SMJ) was, it may be that fish had more refuges to escape fishing. The nets may also be fragments washing into the area and being caught on coral.

Very low numbers of fish were seen at both Bawmi Aww (0.5 ± 0.2sd) and the inshore side of White Sand I (0.8 ± 0.5sd). Both Bawmi Aww and the inside of White Sand Is are relatively close to shore and accessible in all weather. At Ma Gyi, inshore sites had fewer fish than offshore sites, which may also be a function of accessibility. Certainly at low tide, a large number of individuals can be seen working the shallow areas with hand nets and seine nets (pers. obs. SM-J).

We found a mean number of 50 fish (± 61sd) per transect fish per transect. Howard *et al.* (2014) do not give a mean number of fish overall per transect, but did give mean numbers of fish counted using Reef Check methods which are included for comparison using data from the April/May surveys. Snapper were the most common fish in both locations, with 22 (± 7se) snapper per transect on the Mawtin Coast compared to Tanintharyi (9 ± 1). Similarly butterfly fish (Mawtin 11 ± 1 cf 4 ± 1se) and parrot fish were more common on the Mawtin coast (Mawtin 11 ± 2 cf 4 ± 1 se).

All sites had at least low levels of fishing gear. The highest amount in April was found at North Bird I, although interestingly the north side of North Bird I in December had no fragments of net. We found less net fragments in December than in April at South Bird I. This could be due to less fishing pressure over the wet season (which did not end until November in 2016), or some very rough weather in November due to cyclones passing though the Bay of Bengal in November (pers. obs. SMJ), which may have dislodged net fragments.

Physical impacts from tourism, including divers, snorkelers and boats can be an issue as well. On the Mawtin coast, there is as yet few diving and snorkelling opportunities, but there is much development in tourism, especially local tourism, as coastal roads and bridges, along with resorts, are being constructed (pers. obs. SM-J), and there is now a dive centre operating in Ngwe Saung. This infrastructure development is likely to add pressure to the marine habitats. There appears to be an increasing amount of local tourism, largely centred around Chaung Tha and Ngwe Saung offshore islands. We observed the highest anchor damage around the Bird Is, but no sites ranked particularly highly (unpublished data).

Many of the sites visited seemed to be recovering from very large past mortality, which may have been due to the 2015 world mass bleaching event (see Resilience Assessment, below). Early 2016 saw the biggest bleaching event ever recorded on Australia's Great Barrier Reef (Great Barrier Reef Marine Park Authority, 2016). We did not score for bleaching, due to lack of training time. Other factors that affect reefs in the region include cyclones, terrestrial sediment run-off, predator outbreaks such as crown of thorns, and anthropogenic threats such as fishing, pollution, and nutrient additions. These factors are likely to be synergistic as development pressure increase, for example herbicides make corals more vulnerable to rising temperature (Negri *et al.* 2011), and nutrient loading can make corals more susceptible to disease (Bruno *et al.* 2003).

2.4.2 Resilience assessments

Overall, fishing pressure appears to be the major resilience driver for all of the sites surveyed, exerting a greater or lesser control on coral health and ecosystem services provided by fish guilds. A variably large proportion of partial mortality, physical damage and overall weakening of the systems can be attributed to intensive fishing, particularly from hookah-equipped divers who are said to target crayfish using chemicals, and those who spear herbivorous fishes at night. In general, most sites were reasonably well-supplied with coral recruits, but the numbers were not sufficient to keep pace with losses due to disease. Substantial numbers of recently dead corals at all sites indicates a recent, large-scale mortality event (possibly associated with the 2015 world mass bleaching event) that has reduced numbers of adult colonies by up to 40%. Ongoing disease outbreaks (primarily white syndrome) significantly reduce the ability of the community to recuperate, and are adding significantly to the scale of the mortality (or may be entirely responsible for it). A paucity of reef fishes, particularly mesopredators has unbalanced the ecosystems in almost all sites; this is compounded by the depauperacy of large ecosystem modifying species.

Perhaps surprisingly, the areas with most tourism activity exhibited the most potential resilience. This appears to be because the tourism activity seems to have some slight restraining action on the fishery (probably because a proportion of the fishers have shifted to tourism as a more stable income source, rather than because they feel constrained by the tourism businesses). Where fishing appears to be unhindered, the outcomes for the coral communities are less assured. From the summary table above, it would seem that the most consistent resilience indicator/driver is to do with fishing intensity and breadth of catch (Table 2.2). It is likely that co-management of the areas around Ngwe Saung and Chaung Tha to enhance the sustainable marine tourism market could have a positive influence on the viability of the coral communities there. Reducing the intensity of fishing in the other sites may help the areas recover.

Table 2.2: Summary table of resilience factors 2016.

Site	Management	Fishing influence	Tourism Influence	Coral Community	Fish Community	Overall
Ngwesaung	None (informal tourist/fisher)	moderate/ high	Moderate	Variable: Poor-good Low disease Low recruits	Sparse-low, reasonably diverse	OK
Chaungtha	None	High	Moderate	Variable: Poor-good Moderate disease Low recruits	Very sparse, reasonably diverse	OK
Shwetaungnan	None	High	Low	Low diversity, high disease, moderate recruits	Sparse, poor diversity	poor
Jate Late	None	Very high	Low	High diversity Moderate disease Low recruits	Sparse, poor diversity	Very poor

In the 2016 snapshot survey, two of the sites surveyed here (Shwethaungyan and Chaung Tha) were examined non-quantitatively for general condition, community characteristics and resilience drivers. Here, these impressions will be compared with the data presented in the previous section to provide insights into community and resilience factor changes over the past three years.

Shwethaungyan 2019: Shwethaungyan appears to have been heavily affected by the disease outbreak recorded in 2016, resulting in considerable mortality amongst the vulnerable *Acropora* community. This disease may not have entirely disappeared from this area, as the offshore site (while retaining a rich and comparatively healthy coral population) exhibited considerable partial mortality that is likely a result of disease infection. All sites appear to receive some degree of replenishment; however, there appears to be some decline in live coral cover compared to 2016.

Although fish and invertebrate counts were not undertaken during the 2019 survey, by inspection the fish communities of the Shwethaungyan sites were diminished compared to 2016. There was an abundance of fishing gear at all sites, and it is likely that this area is under intense fishing pressure (a negative change from 2016). The large schools of small lutjanids, acanthurids and scarids visible in 2016 were not apparent in 2019.

Chaung Tha 2019: Some disease amongst living coral colonies suggests that the cause of the high proportion of dead and diseased corals recorded in 2016 has not entirely disappeared. Dead coralla were largely absent (likely broken off in monsoonal storms after extensive bioerosion by the many sea urchins present at the site, which can weaken the corallum pedestal). Coral cover on the ridges has increased since 2016 (from 10-70% to average 85%), although coverage is patchy, the mix of taxa has remained relatively consistent. Recovery has been extremely rapid at this site, despite the relative sparseness of juveniles reported in 2016, although it should be noted that high coral cover only occurs on the upper surfaces of the ridges, and is patchy elsewhere. The previous survey noted that around 30% of live coral had been lost at that time, suggesting that the community still has considerable ground to make up.

The persistence of disease and partial mortality at this site in 2019 indicates that the threat to community integrity remains. The lack of juvenile corals at Chaung Tha is worrisome from a resilience standpoint, and indicates a potential threat to the integrity of the community. The recovery may be the result of one or two large pulses of recruits that are not consistent each year, which diminishes the overall resilience of the area. Partial mortality appeared to be associated mainly with

fishing activity and boat anchors associated with the burgeoning tourism industry (including SCUBA).

Broken corals and overturned corals were not uncommon at this site. Negligent anchoring practices by tour boat drivers and fishermen represent considerable risk for a community composed largely of tabulate corals.

The 2016 survey noted an abundance of planktivores, mostly caesionidae and pomacentridae, but few larger fishes, and no mesopredators such as lutjanids, carangids, lethrinids or serranids. This trend was apparent in 2019, as well, although schools of pempherids were also visible. Numerous small labrids and scolopsids were present in 2019, however the poverty of mesopredators remained.

Survey boat, near Shwethuaungyan.

CHAPTER 3. SEAGRASS

Authors: U Soe Htun and Sue Murray-Jones

3.1 Introduction

Seagrasses are a group of submerged flowering plants of approximately 72 species, living in shallow oceans and estuaries around the world (Short *et al.* 2007). Seagrass meadows provide a range of valuable ecosystem services, both direct and indirect (e.g. Orth *et al.* 2006), and seagrasses are key primary producers. Many commercial species such as prawns and fish are dependent on seagrass systems (Coles *et al.*, 1993). Seagrasses provide shelter and nursery grounds for many species, and provide food for animals such as dugongs, turtles, water birds and a range of invertebrates (Björk *et al.* 2008, Costanza, 1997). Seagrasses stabilise sediments and prevent erosion, remove suspended sediments and nutrients from the water column, and sequester carbon (Fourqurean, 2012; Fonseca and Fisher, 1986). Light is the primary factor controlling seagrass productivity and distribution. Light availability is reduced by environmental factors such as water depth, turbidity, latitude, and wind speed (Short *et al.* 2007). The tropical Indo-Pacific has the highest seagrass biodiversity in the world, with many species found in mixed meadows with no clear dominant species (Short *et al.* 2007).

Since 1980, about 60% of seagrass populations globally have seen a reduction in their distribution due to habitat destruction and marine pollution (Short and Wyllie-Echeverria 1996, Orth *et al.* 2006). Stressors include land-based inputs of nutrients and sediments, aquaculture, pollution, boating, construction, dredging and landfill, and destructive fishing practices. Potential threats from climate change include rising sea levels, changing tidal regimes, heat damage and die back (e.g. see Seddon *et al.* 2000), sediment anoxia, and increased storm and flooding events (Björk *et al.* 2008).

Seagrasses occur all along three coastal regions of Myanmar, the Rakhine coast, Ayeyarwady Delta and the Gulf of Mottama and Tanintharyi coast. Ten species of seagrasses have been described in Myanmar (Soe Htun, 2015). Myanmar people are well aware of the importance of seagrass, calling seagrasses leik-sar-phat-myet, meaning the food of marine turtles (Soe Htun, 2015).

The studies described in this report were undertaken to provide updated information on the current status, distribution and coverage of seagrasses at selected sites within the Rakhine coastal region of Myanmar. SeagrassNet survey methods were adapted to suit local conditions. SeagrassNet is a global monitoring programme based at the University of New Hampshire which has developed protocols for monitoring (Short *et al.* 2006). Using a standard seagrass methodology enables regional comparisons and SeagrassNet has been previously used by U Soe Htun in Myanmar (Soe Htun *et al.*, 2015, 2009), and taught to a generation of Myanmar marine scientists.

3.2 Method

3.2.1 Site selection

Sites were chosen using available imagery and local knowledge. It was difficult to differentiate between silt-covered seagrass, and silt covered rocks and algal mats either from headlands or aerial photos, and despite assurances from local villagers and fishermen, often “seagrass” turned out to be algal-covered rock. Hence around 80 sites were visited and investigated via snorkel to determine whether there was seagrass present. Figure 3.1(a) shows sites where transects were carried out, while Figure 3.1(b) shows all sites investigated for seagrass.

The first trip was conducted in March, 2016, and focussed on sites from Ngwe Saung in Ayeyarwady Region to a little north of Gwa in Rakhine State. A second round of surveys, focussing on the southern part of the Mawtin coast from Ngwe Saung to Nga Yoke Kaung, were carried out in November 2016. The second set of surveys were complicated by an unusually prolonged monsoon, with two cyclones passing though the Bay of Bengal during the survey period. Torrential rain during the survey period meant visibility at some sites was close to zero and we were unable to do quantitative surveys at a number of sites that may have been large enough to survey. Further transects were conducted at Ma Gyi and Pho Htaung Bay in February 2018 prior to a survey from Cape Negrais up to Nga Yoke Kaung.


(a)
93°30'0.0000"
94°0'0.0000"
94°30'0.0000"
17°30'0.0000"
17°0'0.0000"
16°30'0.0000"
16°0'0.0000"
Yay Myet Taung
Chan Pyin
Gwa
Gyaing Kauk
Baw Di
Jadalet/Bawmi Aww
Pho Htaung
Wetthe
Shwethaungyan
Poe Laung
Ma Gyi
Thabaung
Chaung Thar
Ngwesaung
Bay of Bengal
Tharthanar Dauk
Ngayokekaung
Ngapudaw
Labutta
Hainggyikyun
Legend
Town
Villages
Road
Seagrass Survey Sites
SeagrassNet2016
SeagrassNet2018
0 7.5 15 km
Thimphu
BHUTAN
Guwahati
Lijiang
Kunming
YUNNAN
Dhaka
TROPIC OF CANCER
Khulna
Chittagong
Mandalay
MYANMAR
BURMA
LAOS
Sittwe
Nay Pyi Taw
Pathein
Mawlamyine
Yangon
THAILAN
Bangkok
Myeik
Andaman Sea
Gulf of

Figure 3.1(a): Map of sites quantitatively assessed for seagrass. Symbols: red star, SeagrassNet transects 2016; green triangle, SeagrassNet transects 2018; (b) map of all sites investigated (open circles), presence/absence data only except for sites in (a).

3.2.2 Identification

All specimens were identified using the standard monograph of seagrasses prepared by den Hartog (1970), and Kuo *et al.* (2006). All voucher specimens were deposited at the Herbarium of the Department of Marine Science, Mawlamyine University, Myanmar.

3.2.3 SeagrassNet

The standard SeagrassNet method is to use three 50 m transects, all shore normal. One is close to the inshore edge of the meadow (A), one close to the offshore edge (C) and one in between (B) (Short

et al. 2006); however, due to the fact that many seagrass meadows in the Rakhine coast area are subtidal, and water visibility is generally poor, it was not always possible to locate the outer edge. In this instance, the transect tape was deployed as far out as possible (boats were not available at most sites, and the distance out was limiting both scuba divers and snorkelers for larger patches).

Twelve 0.25 m^2 quadrats were placed at random distances along the tape for each transect. A visual estimate of seagrass cover was made for each quadrat, species recorded and photographs taken. Herbarium specimens were collected from each site. At one site, Poe Laung, fading light, added to a large number of seasnakes in the seagrass meadow, meant we were only able to sample transect A and B.

For the first site, core samples were initially taken in order to estimate biomass, and canopy height and shoot density recorded. However, due to a combination of strong winds, poor visibility and inexperienced divers, it was not possible to complete collecting these parameters, and for the rest of the surveys, only species and percent cover were recorded. Data were collected by wading where the seagrass was intertidal or partially submerged, and by diving and snorkelling in deeper water. Maximum depth recorded was 5m.

For sites where no quantitative survey was possible due to poor conditions, samples were collected and identified to species, and pressed as herbarium specimens. Presence or absence of seagrass was noted, along with GPS points and a brief description of habitat for all species. Presence/absence data were collected for over 50 sites. We only found seven sites in March and two in November 2016 where there was both a meadow large enough to survey quantitatively (minimum 100m by 50m patch), as well as adequate visibility/weather conditions, and only one small clump between Nga Yoke Kaung and Cape Negrais.

3.3 Results

3.3.1 2016

Some areas of seagrass were extensive, and cover varied from high to very sparse or may be restricted to a few plants amongst rocks, and range from intertidal meadows to solely subtidal areas (Figure 3.3), with the majority of sites extending into the subtidal. At two sites, seagrasses were confined to patches of sediment trapped on intertidal rocky platform reefs (Yay Myet Taung and Baw Di, Figure 3.2a), with no subtidal component.

In the sites surveyed during the monsoon season (which ended around 6 weeks later than normal in 2016), many seagrasses were partially buried (Figure 3.2b).

Figure 3.3: (a) Extensive intertidal meadows; and (b) patchy subtidal seagrass interspersed among rocks. Ma Gyi.

Figure 3.2: (a) Patchy seagrass interspersed amongst rock on intertidal wave cut rock platforms at Baw Di; (b) *Halophila decipiens* partially buried at Leik Kyun in November 2016, photo Salai Mon Nyi Nyi Lin, FFI.

We found seagrass at 14 sites out of 52 visited. Overall only nine sites had large enough meadows or enough visibility to survey. In all, 10 species were found (Table 3.1a,b). Only one site, Pho Htaung, had all 10 species.

For the sites actually surveyed, the most common species found were *Halodule pinifolia*, which was found at eight sites, and *H. uninevis*, which was found at seven sites. There was a mean number of 4.7 (± 0.9, s.e.) species per site, varying from two to ten species. No surveyed sites were monospecific, although some deeper water sites assessed (but not actually surveyed) appeared to be e.g. Leik Kyun, where only *Halophila decipiens* was found; however, very poor visibility may have meant we missed any other species. The two sites with the least diversity (only two species each) included both the most northerly site (Gyaing Kauk) and the most southerly (Ngwe Saung).

(a)

		.	Locality (Date)	Position	Cover (%)/ Cross-transect				Species										
					A	B	C	Total ±se	*Si*	*Cr*	*Cs*	*Hu*	*Hp*	*Ea*	*Th*	*Hb*	*Hd*	*Hm*	Total
Rakhine Coastal Region	**Ayeyarwady State**	1.	Ngwe Saung (14-3-2016)	Lat 16.913734, Long 94.386513	35.4	48.6	53.6	45.9 ±3.4					+				+		2
		2.	Ma Gyi (12-3-2016)	Lat 17.072122, Long 94.452406	34.1	40.8	36.6	37.2 ±6.3	+	+	+	+	+		+		+	+	8
		3.	Pho Htaung (12-3-2016)	Lat 17.171497, Long 94.492649	69.1	64.6	-	66.9 ±6.8	+	+	+	+	+	+	+	+	+	+	10
	Rakhine State	4.	Baw Di (17-3-2016)	Lat 17.49449, Long 94.560941	3.3	18.3	14.6	12.1 ±3.0			+	+	+						3
		5.	Chan Pyin (16-3-2016)	Lat 17.645493, Long 94.564282	67.9	37.3	61.7	55.6 ±5.2			+	+	+	+			+		5
		6.	Yay Myet Taung (19-3-2016)	Lat 17.713223, Long 94.532931	44.6	54.2	14.8	37.9 ±5.3				+	+		+				3
		7.	Gyaing Kauk (18-3-2016)	Lat 17.494505, Long 94.560961	28.8	49.2	34.2	37.4 ±3.5					+					+	2
Total Sites (Occurrence)									2	2	4	5	7	2	3	1	4	3	

(b)

			Locality (Date)	Position	Cover (%)/ Cross-transect				Species										
					A	B	C	Total	*Si*	*Cr*	*Cs*	*Hu*	*Hp*	*Ea*	*Th*	*Hb*	*Hd*	*Hm*	Total
Rakhine Coastal Region	**Ayeyarwady State**	1.	Tharthanar Dauk (4-11-2016)	Lat 16.60744, Long 94.32393	52.9	32.2	23.7	36.3 ±3.3			+	+						+	3
		2.	Wetthe (12-11-2016)	Lat 17.14155, Long 94.46521	28.5	46.6	52.5	42.5 ±3.8	+		+	+	+		+			+	6
Total Sites (Occurrence)									1	0	2	2	1		1			2	

Abbreviations: Si-Syringodium isoetifolium; Cr-Cymodocea rotundata; Cs-Cymodocea serrulata; Hu-Halodule univervis; Hp-Halodule pinifolia; Ea-Enhalus acoroides; Th-Thalassia hemprichii; Hb-Halophila beccarii; Hd-Halophila decipiens; Hm- Halophila major.

Table 3.1: Coverage (±se) and biodiversity of seagrasses for the Rakhine coast, sites listed from south to north, (a) February 2016 surveys; and (b) November 2016 surveys

Distribution of seagrasses at the nine sites where surveys were conducted was very patchy, ranging between 0 and 100% cover at the quadrat level, and 3 and 69% at the transect level. Baw Di had the lowest cover, with 12.1% (± 3, s.e.) cover over the site (all 36 quadrats), while Pho Htaung had the highest cover, 66.9% (± 6.8, s.e.) (Figure 3.4). Percent cover also varied between sites, with a mean cover of 41.3% (± 5.0, s.e.). The highest covers recorded were at Pho Htaung (66.9 %) and Chan Pyin (55.6%), while the lowest was Baw Di (12.1%).

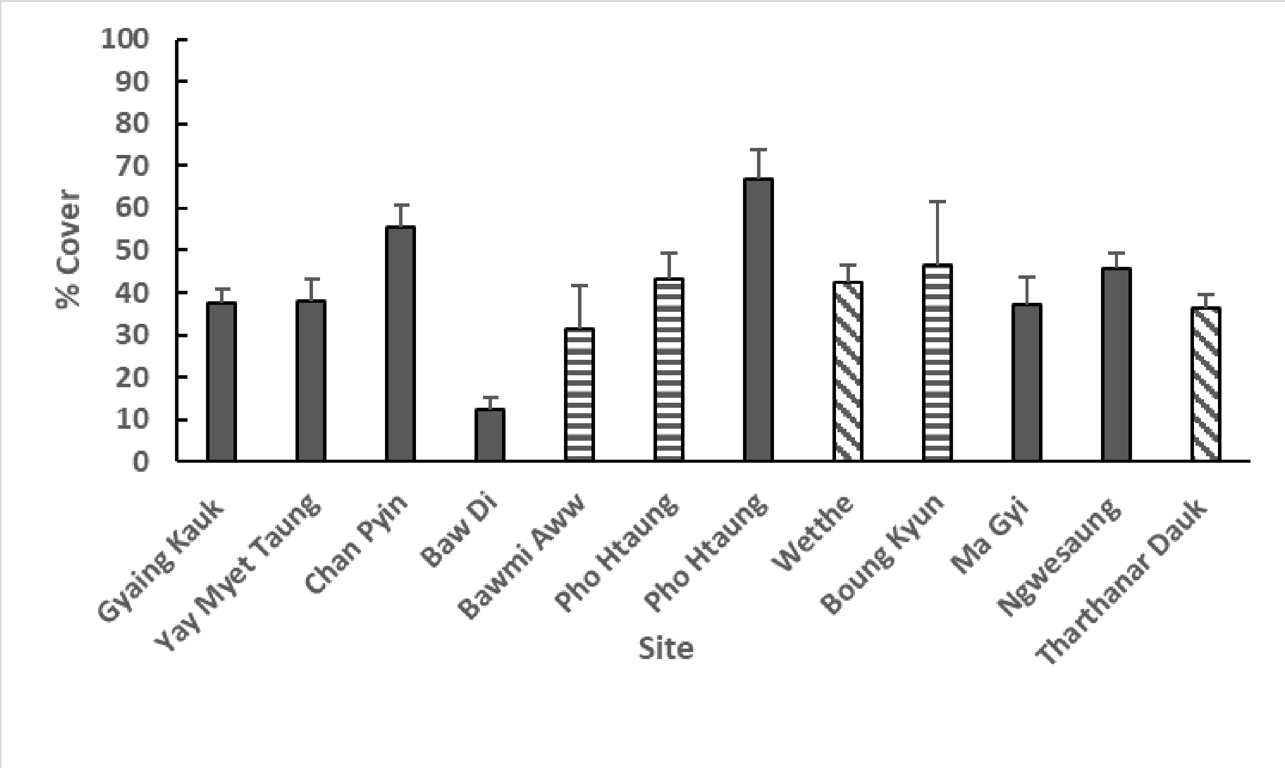


Figure 3.4: Mean seagrass cover at sites on the Myanmar Mawtin coast, arranged from north to south, using SeagrassNet methods. Surveys were completed in March 2016 (solid bars), November 2016 (hatched) and February 2018 (Vertical lines). Figures are generally means of 36 quadrats ± standard error, although a few sites had missing data.

3.3.2 2018

A total of 29 sites were assessed for seagrass in February 2018 to check for seagrasses. Among these survey sites, we found seagrass at seven sites: the mouth of Nga Yoke Kaung tidal creek, Inndin Gyi, Boung Kyun, Thaephyu Kyun, Kyauk Nagar, Pho Htaung and Bawmi Aww (Figure 3.4).

A total of 10 species of seagrasses were recorded during this survey: *Syringodium isoetifolium, Cymodocea serrulata, C. rotundata, Halodule uninervis, H. pinifolia, Enhalus acoroides, Thalassia hemprichii, Halophila beccarii, H. decipiens* and *H. major* (Table 3.2).

Table 3.2: Coverage (±se) and biodiversity of seagrasses for the Rakhine coast, sites listed from south to north, February 2018 surveys.

Locality (Date)	Position	Cover (%)/ Cross-transect				Species										
		A	B	C	Total	*Si*	*Cr*	*Cs*	*Hu*	*Hp*	*Ea*	*Th*	*Hb*	*Hd*	*Hm*	Total
Bawmi Aww (7-2-2018)	Lat 17.29537, Long 94.5158	10.1	37.9	31.6	31.6±10		+	+	+	+				+	+	6
Pho Htaung (6-2-2018)	Lat 17.17442, Long 94.49212	58.3	32.5	43.8	43.3±6.1				+	+	+			+		4
Boung Kyun (8-2-2018)	Lat 17.084, Long 94.448	61.7	17.2	61.2	46.7±14.7	+		+	+			+			+	5
Total Sites (Occurrence)						1	1	2	3	2	1	1	0	2	2	

Abbreviations: Si-Syringodium isoetifolium; Cr-Cymodocea rotundata; Cs-Cymodocea serrulata; Hu-Halodule univervis; Hp-Halodule pinifolia; Ea-Enhalus acoroides; Th-Thalassia hemprichii; Hb-Halophila beccarii; Hd-Halophila decipiens; Hm- Halophila major.

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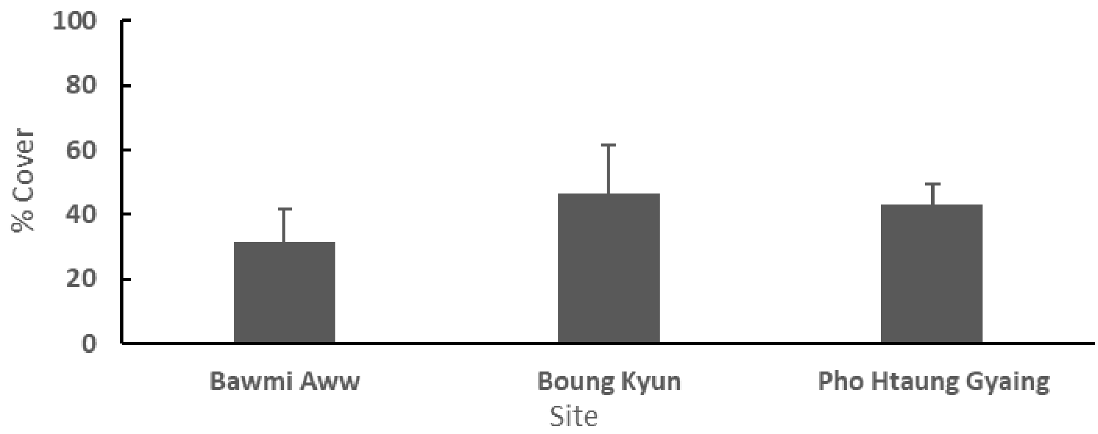
Only three sites had sufficiently large amounts of seagrass to use the SeagrassNet transect method: Boung Kyun, Pho Htaung and Bawmi Aww on the central Mawtin coast. Of these, Bawmi Aww had the highest species richness, with 6 species found (Table 3.2), but cover was patchy. Boung Kyung had the highest percent cover, at 47% (±15, s.e., Figure 3.5). Pho Htaung had a cover of 43% (±6, s.e.). Cover was very patchy at all sites, with extensive bare patches.

On the southern Mawtin coast between Cape Negrais and Nya Yoke Kaung, we found only one very small clump of seagrass. *Halophila beccarii* was only recorded at Chaung Wa near Nya Yoke Kaung.



3.4 Discussion

Figure 3.5: Mean seagrass cover at three sites on the Myanmar Mawtin coast, arranged from north to south, using SeagrassNet methods. Surveys were completed in February 2018 . Figures are means of 36 quadrats ± se.

Distribution of seagrasses was very patchy, with cover varying from high to sparse, and ranged from solely intertidal, solely subtidal, or both. The majority of sites encompassed both.

A previous study incorporating three sites in the Rakhine coastal area and 10 sites in the Tanintharyi showed differences in distribution, with seagrass meadows in Tanintharyi most commonly observed in the intertidal zone, while those in Rakhine were more likely to be found in the subtidal zone (Soe Htun, 2015). This was in agreement with our results. In the previous study, species diversity at Ma Gyi and Pho Htaung Gyaing with nine species was highest compared to other sites, in close agreement with eight and ten species found respectively in the current study at these sites. Thaung Htut (2011) sampled the Ma Gyi area between August 2010 and February 2011. He also found a total ten species of seagrasses, with the highest species richness also at Pho Htaung Gyaing (all ten species), with six species at Chaung Tha, eight at Ma Gyi, and seven at Wetthe. In 2018 we found six species at Bawmi Aww, five at Boung Kyun, and four at Ma Gyi.

Light availability is well known to limit seagrass distribution (e.g. Ralph *et al.* 2007), and it is likely that light is the predominant limiting factor for the Mawtin coast, which has generally poor visibility inshore, especially after rain or with any swell. We found surprisingly little occurrence at seagrass at sites south of Ngwe Saung on the November surveys for sites we would have expected to be favourable for seagrass, and heavy sedimentation meant that some areas were partially buried. Visibility was less than 0.5 metres at most sites in November. There are also large inputs of fresh water during the monsoon, which could also cause seasonal die off (e.g. Bandeira and Gell, 2003). Hence the occurrence of seagrasses may be seasonal, although no rhizome mats or buried shoots were found. In addition, percent covers recorded at the two sites on the Rakhine coast previously surveyed in May 2015 (Soe Htun, 2015) were very close to the values we recorded in February 2016 (for Ma Gyi, 39.3% in 2015 cf 36.6% in 2016; for Pho Htaung, 66.8% in 2015 cf 66.9% in 2016, although only 43.3% in 2018), which would indicate that densities had not fluctuated seasonally (February is well

into the dry season, while November is at the end of a prolonged wet season). The apparent drop from 2016 to 2018 at Pho Htaung was most likely due to the decision to survey a different site within the bay. We chose one that had not been studied before, choosing one which the Small Grants winners would be able to access in all weather via motorbikes, to enable follow up surveys.

Some of the variation within transects and between sites can be explained by the patchy nature of seagrasses in some intertidal areas, and the analysis used. On some rock platforms, there were areas of sediment with often high coverage of seagrass interspersed with rock. When a preselected quadrat fell on bare areas of rock, even those that would not be submerged often, these quadrats were scored as zero, even though no seagrass could have ever been present. It would be more correct to exclude them, and further training will address this issue.

This study provides presence/absence data for seagrasses, and a species list incorporating over 50 sites in the Rakhine coastal area. It provides a replicable baseline for the twelve seagrass sites which were substantial enough to survey, which will allow long-term monitoring of seagrass beds and allow the impact of coastal developments and any management interventions aimed at seagrass conservation to be assessed. In addition, to date 86 staff and students of the Myanmar Marine Science Departments have received extensive training in seagrass assessment, and have become adept at using SeagrassNet methods in the intertidal and shallow subtidal.

Halophila *sp. (Salai Mon Nyi Nyi Linn/FFI)*

CHAPTER 4. MANGROVE HABITATS

Authors: Stefano Cannicci, Ayyappan Saravanakumar, Muthuvel Arumugam and Sue Murray-Jones

4.1 Introduction

With a coastline of around 2400 km, plus offshore islands and large estuarine systems, including the Ayeyarwady Delta, Myanmar possesses extensive mangrove systems. Within Southeast Asia and the Pacific, Myanmar has the largest area of mangroves (following Malaysia, Bangladesh and Papua New Guinea, Holmes *et al.* 2014). Mangroves are the most studied marine system in the country, with many studies, theses and reports on Myanmar's mangroves, often with a particular focus on the Ayeyarwady Delta region.

Myanmar has 32 known mangrove species and forms a biogeographic transition zone between the South-East Asian and the Indo-Andaman regions (Spalding et al. 2010). Myanmar's mangrove forests have been considerably depleted and degraded over the last few decades from charcoal production, agricultural expansion and conversion to fishponds, shrimp ponds and rice paddies (e.g. Zöckler and Cherry Aung 2019) and it has been estimated that Rakhine Region has lost 42% of its mangroves (Holmes *et al.* 2014). The disappearance of mangroves has been linked to the extensive loss of lives in Cyclone Nargis in May 2008 (Spalding *et al.* 2010) which further devastated the mangroves of the Ayeyarwady.

It has been suggested that Myanmar mangroves have been disappearing faster than for other countries in the region (Giri *et al.* 2000). Losses were particularly acute in the Ayeyarwady Delta last century (Spalding *et al*. 2010; Zöckler and Cherry Aung 2019), with 24% lost by 1984 (Oo, 2002), and another 20% lost prior to 2000 (Leimgruber *et al*. 2005). While extensive mangroves remain, they have been highly degraded by logging for timber and charcoal.

In January 2018 on the Mawtin coast, Ayeyarwady Region, Myanmar, surveys of mangrove habitats, along with training for staff and students were led by A/Prof. Stefano Cannicci from the University of Hong Kong. The objectives were to undertake habitat surveys of the mangrove forests of the Mawtin coast around Ngwe Saung and Nga Yoke Kaung (Figure 4.1), including species composition, descriptions of the vegetation community, densities and canopy heights, and degradation level.

In 2019 A/Prof Ayyappan Saravanakumar and Dr Muthuvel Arumugam from Annamali University, India also conducted training and surveys, mainly around the University of Pathein's field station at Ma Gyi (Figure 4.1)

This chapter is compiled from the two consultants' reports, Cannicci, 2018, and Saravanakumar and Arumugam (2019).

Additionally, during the bird surveys of the Mawtin coast (Chapter 6), Zöckler also developed a classification system for mangroves (one of the major bird habitats on the west coast), which included ranking some mangrove sites, which has been summarised in the current chapter. A detailed habitat classification based on satellite imagery and using the observations and photos from this survey for ground-truthing has been produced by ERA and ArcCona, which has been submitted as a separate, stand-alone report (Harris 2016), with land use and mangrove cover maps for the Mawtin coast.

4.2 Method

4.2.1 Habitat classification

In order to rapidly assess the condition of the mangroves, Zöckler developed classification criteria during the bird surveys described in Chapter 5 (Harris 2016, Zöckler *et al*. in press)). The criteria describe the observed state of impact, which often looks different on the ground than on satellite imagery. A scale from 1-6 was used, ranging from 1: clear-cut to 6: not impacted and ecologically intact. This scale allows a rapid assessment tool to quickly assess the status and level of degradation during a brief visit only. Even though the assessment often is based on the sea front or from the channel, the state of the mangroves can be assessed up to 500 meters deep and in the experience

of the survey team, the height or density of the mangroves rarely changed towards the back of the forest.

4.2.2 2018 Mangrove surveys

Only the plants categorized into exclusive (true) mangrove species (*sensu* Tomlinson 2016) were measured.

i Mangrove habitat survey: the Point-Centred Quarter Method

The surveys were carried out in three separate forest areas along the Mawtin coast in Ayeyarwady Region in January 2018. Different numbers of transects was conducted for each site, determined by the overall dimension of the mangrove forest. Five transects were performed in the forests around Nga Yoke Kaung, at Tuu Myaung and Nga Pu Taw Township; two in the delta of the Tazin river (Ngwe Saung); and two in the delta of the Yay Thoe river (Ngwe Saung, Figure 4.1).

The ecological status of the mangrove areas of Mawtin coast have not been assessed in recent years, thus an in-depth habitat survey was necessary to design a long-term monitoring plan for these forests. Among the few standard techniques developed to ground-survey mangroves and to assess their ecological health, the Point-Centred Quarter Method (Cintron & Schaeffer-Novelli 1984; Dahdouh-Guebas & Koedam 2006; Khan *et al.* 2016) was selected for the survey. This technique produces standard forestry measures such as basal area/ha, tree density/ha and average height, allowing the results to be compared to mangrove forests worldwide. Surveys based on this method can be carried out with the help of two or three people. In addition, the method was chosen as the consultant was part of the Point-Centred Quarter Method development team and already uses this methodology in Sri Lanka and Malaysia.

The technique consists of surveying linear transects in different and ecologically homogeneous areas of a mangrove forest, previously designated with the help of a vegetation map. The number and length of those transects depends on the overall size of the mangrove area. Along each transect, at least 15 centre points are set at distances depending on the overall length of the transect itself. Each centre point divides the adjacent mangrove area into four 5 × 5 quadrats. In each quadrat, an adult mangrove plant which is the closest to this centre point is chosen to measure. The species of the tree, its height, its circumference at chest height and its distance to the centre point are measured. In two of the four quadrats defined, counts were made of cut stumps of between 130 and 35mm diameter, the number of saplings and of juvenile trees. A fish-eye photograph of the mangrove canopy was taken, and the salinity of pore water was recorded using a portable refractometer.

The main method utilised for measuring the tree height was the use of clinometers (SUUNTO PM-5/360 PC) and, for small trees, the use of metal tape measures (5 m long). Tape measures were also used to measure the distance of the measured trees from the centre point and its chest height circumference.

Apart from this quantitative sampling, the whole team also recorded the occurrence of species of interest, even outside the sampled quadrats. Particular care was taken with recording species classified as Critically Endangered, Endangered, Vulnerable or Nearly Threatened in the IUCN Red List of Threatened Species[4].

[4] http://www.iucnredlist.org/

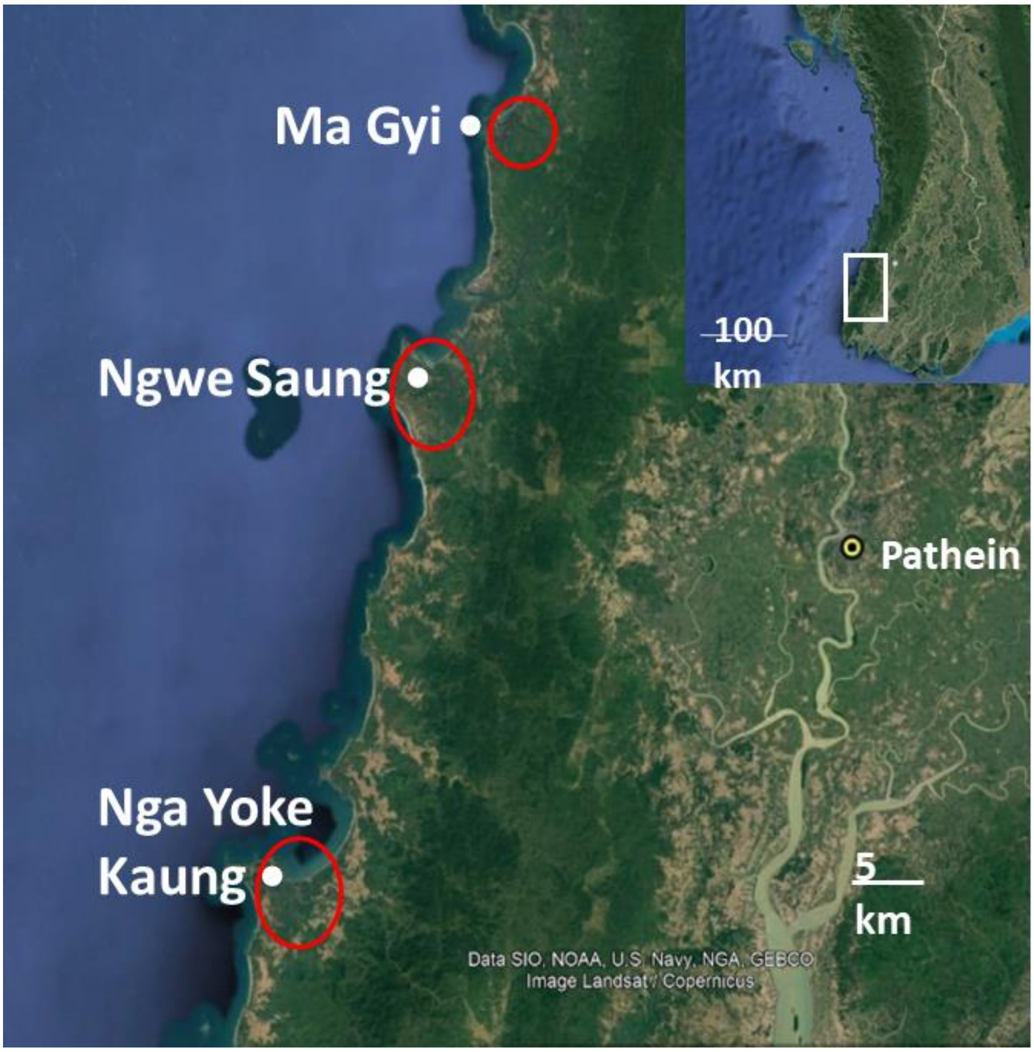


Figure 4.1: Map Showing the position of three mangrove areas surveyed along the Mawtin coast: Nya Yoke Kaung (Tuu Myaung forest, 2018); Ngwe Saung area (Tazin and Yay Thoe River estuaries, 2018); and Ma Gyi (Ma Gyi and U To Creeks, 2019). Google Maps.

ii Mangrove degradation assessment

The degradation level of habitats, and of mangroves in particular, is a sensitive issue, since it is not easy to utilise objective and verified parameters. The mangroves of the Mawtin region visited looked extremely degraded, and in most cases direct anthropogenic impacts appeared to be involved. To account for these issues a number of measures of degradation were utilised,

We estimated a Complexity Index, directly derived from the analysis of the point-centred data. This index computes the spatial structure and complexity of the canopy of a mangrove forest by combining tree height, number of species, tree density and basal area (Blanco *et al.* 2001). This index was computed with the help of the P-DATA PRO programme, version 4.02, a Microsoft® Excel-based Workbook (Dahdouh-Guebas & Koedam 2006). A complexity index based on mean tree height was utilised, because of the amount of disturbance.

The method developed by Dr Christoph Zöckler (Harris 2016) was also utilized (see section "Habitat Classification" above), since some of the members of the research team were previously trained with this scale. The scale describes the area surrounding the sample point including average height, presence of trees over 20 cm circumference at breast height, forest form and levels of logging.

In addition to the above methods, two parameters were recorded in the field. The number of cut branches or stems over 35 mm diameter from the four sample trees at each centred point and a count of cut stems with a minimum of 35 mm diameter within one of the quadrats, randomly selected.

The number of juvenile trees and samplings was also recorded in one of the four quadrats defined at each centred point. A healthy mangrove forest is a forest capable of recruitment of propagules and in which juvenile stages of trees can grow abundantly. A high regeneration index, calculated on the bases of the number of saplings and juvenile trees, is a clear indication of a healthy mangrove forest.

Fish-eye photographs of the mangrove canopy, using an Olympus Tough TG-5 Compact Digital Camera equipped with a FCON-T01 Fisheye Converter and tripod, were also taken. The analysis of the photos is another widely used method used to assess canopy quality, through the sky/leaf coverage ratio over the sampling quadrat. The lower the ratio, the healthier the mangrove, since a closed canopy provides a pristine habitat for the floral and faunal components of these forests.

4.2.3 2019 Mangrove Surveys

Field training was centred around Pathein University's Ma Gyi field station, at Shwethaungyan (Figure 4.1).

Quantitative data on mangrove vegetation structure in each site was collected by quadrat method during low tides (Cintron and Novelli, 1984). Along transects, running perpendicular to the waterfront, plots of 10x10m were laid at every 50m. In total, 45 plots were laid in five stations in each of two creeks. For each plot, the total number of trees was counted, and tree height, canopy height and width were estimated visually and used to calculate canopy index. Tree circumference at breast height for all trees larger than 25cm was measured. Within each larger plot, sub plots each of 1x1m and 5x5m were laid randomly to enumerate regeneration and recruitment classes. The regeneration class includes germinating saplings, which are less than 50cm tall. The recruitment class includes well established saplings which are more than 50cm but less than 1m tall. Density of mature trees, regeneration and recruitment class was expressed as density per hectare. Tree height, circumference at breast height and canopy index were arranged into different frequency classes to study the distribution and composition of different age classes and to infer their correlation.

4.2.4 Data analyses

All the data recorded on the inventory data sheets were transferred to Microsoft® Excel files. Basic analyses were performed using Excel.

4.3 Results

4.3.1 Habitat classification

All mangrove areas visited in the survey area were impacted by human activity in one way or another. The impact varies from almost clear cut to only a few selected trees taken out. The observed mangrove areas along the Mawtin coast varied from Category 2 (see Table 4.1 for categories): heavily impacted; only small scattered trees left to 4: still large and mature trees are available but the impacts of cutting are clearly visible, with 3 stages in between.

Table 4.1: Ranked Scale of Mangrove Degradation from Level 1-6* for rapid condition assessment. Photos Christoph Zöckler.

Scale	Description	Photo
1	Hardly any mangroves are left. Only stems of former mangroves are visible	
2	Mangroves have been clear cut, **Shape:** low bushes, former stumps and roots still visible **Height**: ~1 meter in height	
3	**Shape**: Small forest **Height** varies between ~2 and 5 meters, but vegetation is dense and bushy with very few larger trees in diameter of 20 cm or more. Logging: Lots of visible logging and cut trees	

4	**Shape**: Mangrove clearly in the shape of forest with gaps in between few larger trees of **Diameter**: 20cm and larger. **Height**: > 8-15 meter. **Logging**: All or most large trees logged	
5	**Shape**: Tall Forest with large trees in open mudflat areas, **Height** >15 m **Diameter:** up to 1 meter **Logging**: Single and few logged trees	
6	**Shape**: Tall Forest with trees in open mudflat areas, spread out widely in between trees	Similar to 5 but no cutting and no signs of logging at all

4.3.2 2018 Mangrove surveys

i Assessment of the status of mangroves of the Mawtin coast

The three mangrove forests survey were both highly biodiverse and appeared to be greatly endangered. Overall, along our transects, we recorded twenty-five species of true mangroves, four of which are listed as Nearly Threatened, Endangered or Critically Endangered, and five mangrove associated species, one of which Nearly Threatened (Table 4.2; Figure 4.2).

Unfortunately, at all sites the human impact on mangroves was clear due to extractive use for firewood and building materials, as well as some clearing for aquaculture ponds. Some areas were almost completely destroyed and there is no apparent management of these area.

Table 4.2: List of species recorded in mangrove forests of the Mawtin coast in January 2018. (IUCN Categories: LC, Least Concern; NT, Nearly Threatened; En, Endangered; CE, Critically Endangered, NL, not listed).

True Mangroves			
Species	**Common name**	**Family**	**IUCN**
Acanthus ilicifolius	Lilac-flowered Holy Mangrove	Acanthaceae	LC
Acrosticum aureum	Golden Mangrove Fern	Pteridaceae	LC
Aegialitis rotundifolia	Northern Club Mangrove	Plumbaginaceae	**NT**
Aegiceras corniculatum	Southern River Mangrove	Primulaceae	LC
Avicennia alba	White Grey Mangrove	Acanthaceae	LC
Avicennia marina	Grey Mangrove	Acanthaceae	LC
Avicennla officinalis	Round-leafed Grey Mangrove	Acanthaceae	LC
Bruguiera cylindrica	Reflexed Orange Mangrove	Rhizophoraceae	LC
Bruguiera gymnorhiza	Large-leafed Orange Mangrove	Rhizophoraceae	LC
Bruguiera sexangula	Upriver Orange Mangrove	Rhizophoraceae	LC
Ceriops decandra	Western Clumped Yellow Mangrove	Rhizophoraceae	**NT**
Ceriops tagal	Rib-fruited Yellow Mangrove	Rhizophoraceae	LC
Dolichandrone spathacea	Trumpet Mangrove	Bignoniaceae	LC
Excoecaria agallocha	Common Milky Mangrove	Euphorbiaceae	LC
Heritiera fomes	Sundri Mangrove	Malvaceae	**En**
Heritiera littoralis	Keeled-pod Mangrove	Malvaceae	LC
Lumnitzera littorea	Red-flowered Black Mangrove	Combretaceae	LC
Nypa fruticans	Mangrove Palm	Arecaceae	LC
Rhizophora apiculata	Corky Stilt Mangrove	Rhizophoraceae	LC
Rhizophora mucronata	Upstream Stilt Mangrove	Rhizophoraceae	LC
Sonneratia alba	White-flowered Apple Mangrove	Lythraceae	LC
Sonneratia apetala	Asian Apple Mangrove	Lythraceae	LC
Sonneratia caseolaris	Red-flowered Apple Mangrove	Lythraceae	LC
Sonneratia griffithii	Griffith's Apple Mangrove	Lythraceae	**CE**
Xylocarpus granatum	Cannonball Mangrove	Meliaceae	LC
Mangrove associated			
Aglaia cucullata	Pacific Maple	Meliaceae	DD
Excoecaria indica	Spiny Milky Mangrove	Euphorbiaceae	DD
Phoenix paludosa	Swamp Palm	Arecaceae	**NT**
Talipariti tiliaceum	Native Hibiscus	Malvaceae	NL
Volkameria inermis	-	Lamiaceae	NL
Vines			
Derris trifoliata	Common Derris	Fabaceae	NL
Finlaysonia obovata	Finlayson's creeper	Apocynaceae	NL

Figure 4.2: IUCN listed species found on the Mawtin coast. *Sonneratia griffithii* (A), *Aegialitis rotundifolia* (B) and *Heritiera fomes* (C).

At all sites, many areas formerly dominated by mangrove are now dominated by the Finlayson's creeper, *Finlaysonia obovata*, which both forms dense aggregations on the substrate, impeding the natural recruitment and establishment of mangrove propagules, and overgrow mature mangrove trees, threatening their survival (Figure 4.3).

Figure 4.3: Degraded mangrove areas dominated by the Finlayson's creeper (A) in Tuu Myaung estuary and without any sign of mangrove regeneration (B), as surveyed in the Yay Thoe river.

ii Mangroves of Nga Yoke Kaung

Five transects were performed in the mangroves of Nga Yoke Kaung (Figure 4.4). Two of them were selected in the downstream area of the estuary, two of them in the intermediate area and one in the upstream area. At all transects, 15 points were marked and a total of 60 sub-quadrats recorded. All transects had been strongly impacted by extractive activities, as shown by the low mean tree height at all sites (Table 4.3**Error! Reference source not found.**). An area looking almost pristine and untouched was only found on the landward belt of transect 5, where trees of *A. officinalis* up to 10 m tall were frequent. The complexity index was extremely low in transects 2, 3 and 4, while it was slightly higher, although still not representing a pristine situation, at transect 1 (mainly due to healthy *N. fruticans* palms) and transect 5 (mainly because the above mentioned belt dominated by *A. officinalis*). Similarly, the degradation index was in between 2 and 3 in all transects but T5. The two transects carried out in the intermediate area were very different, with the first one co-dominated by *C. decandra* (26.8%), *A. officinalis* (23.2%), *R. apiculata* (19.6%) and *N. fruticans* (17.9%) and the second one strongly dominated by *R. apiculata* (60.3%), showing that the intermediate area of this forest is spatially heterogeneous and needs to be studied in more detail. The upstream transect 3 was dominated by *R. apiculata* (57.6%) and *B. gymnorhiza* (15.1%), while in the two transects recorded downstream the dominance of *E. agallocha* (39.8% and 20.3% in T4 and T5, respectively) and *A. officinalis* (23% and 27.1% in T4 and T5, respectively) shows that these transect, or parts of them, and freshwater dominated, as shown by their salinity. The number of juvenile trees recorded in the sub-quadrats was generally low, with the exception of the pristine area dominated by *A. officinalis* in T5, where a higher variability, with subquadrats containing high number of recently recruited saplings, was found.

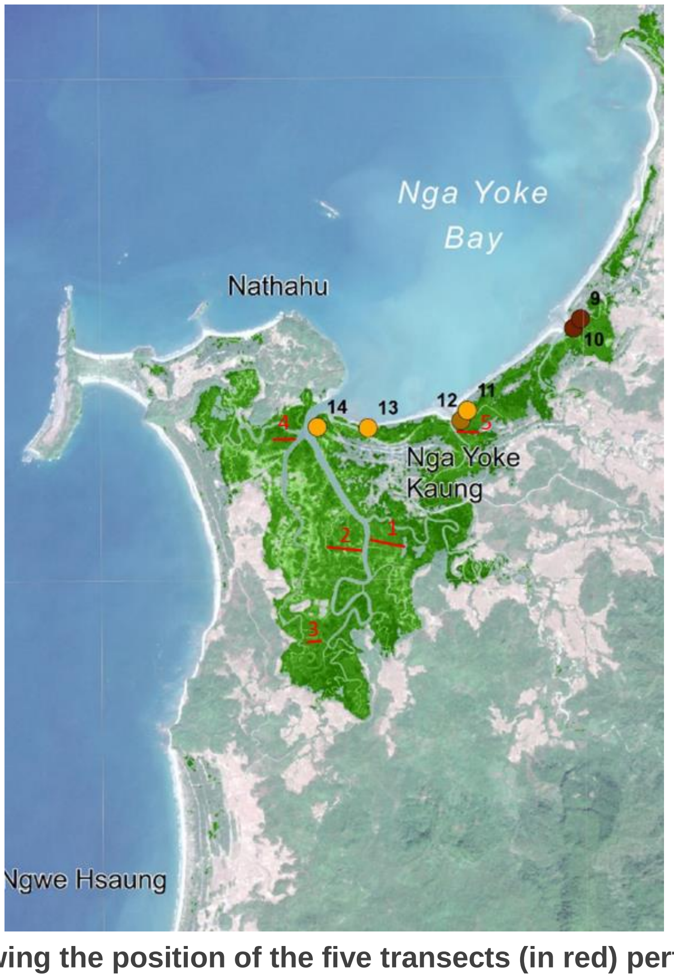


Figure 4.4: Map showing the position of the five transects (in red) performed in the Nga Yoke Kaung mangroves. Map from Harris *et al.* (2016). Other numbers refer to ground truthing points by C. Zöckler from the habitat classification survey.

Table 4.3: Forestry and ecological parameters for transects in the Nga Yoke Kaung mangroves.

Nga Yoke Kaung	T1	T2	T3	T4	T5
Number of tree species	8	9	7	8	9
Mean height (m)	3.7	3.9	3.4	4	5.3
Total forest density (trees 0.1 ha^{-1})	174.4	116.5	222.9	233.6	203.6
Total basal area (m^2 0.1ha^{-1})	7.1	1.3	0.3	0.74	4.23
Complexity Index	36.8	5.5	1.7	5.5	40.8
Degradation Index	2.2	2.7	2.3	2.5	3.5
Mean salinity (± St. Dev.)	31.8 ± 2.3	31.9 ± 3.5	30.0 ± 0	32.0 ± 2.5	30.0 ± 0
No. of juveniles (± St. Dev.)	3.4 ± 3.2	5.2 ± 6.3	1.3 ± 3.2	2.3 ± 2.5	8.3 ± 21.2

We also recorded a number of rare or endangered species. Adult trees of *S. griffithii* (IUCN red list Critically Endangered) were fairly common along the banks of the river near transects 1, 2 and 3, although most of the trees showed some degrees of human impact, such as cut stems. Only one specimen of *E. indica* was found, nearby the end of transect 1, while no more than five small and sparsely distributed shrubs of *A. rodundifolia* were recorded near transect 5.

iii Mangroves of Ngwe Saung

In the Ngwe Saung area, we targeted two different mangrove estuaries, the Tazin River and the Yay Thoe estuary. At both sites, two transects were carried out, T1 and T2 in the Tazin estuary and T3 and T4 in the Yay Thoe one, marking 15 points and 60 sub-quadrats at each one (Figure 4.5). We targeted the intermediate and upstream estuarine areas, where the mangroves seemed less impacted from the satellite images and from a preliminary visit. A great part of the Yay Thoe mangroves appeared to be managed as extensive mangrove crab aquaculture facilities. These areas were delimited by walls, made of mud and stones, and ditches were dug to control the water level in the enclosure. We could not visit the mangroves in those area, although, from an overall look from the outside, the average density and height of the trees look quite similar to the rest of the one we measured at T4.

The mangrove forests around Ngwe Saung (Figure 4.5) were more highly degraded than the Nga Yoke Kaung forest due to extractive activities and other activities such as aquaculture. Large portions of the Yay Thoe estuary are no longer tidal, and the mangroves of transect 4 in Yay Thoe were completely destroyed (Figure 4.6), with not a single tree in 42 out of the 60 recorded sub-quadrats. Other transects showed extensive ecological degradation, as shown by all the parameters recorded (Table 4.4). No area of the transect had mature trees and in Yay Thoe the mean height of trees was less than 3 m. Both Complexity and Degradation Indexes are at their lowest range and the figures for basal area show that trees were very sparse and huge gaps among them are the norm. Unfortunately data for much of Transect 1 are missing. In this destruction scenario, at Tazin the most abundant species at T2 were *R. apiculata* (42.9%) and *C. decandra* (21.4%), which dominated what remains of the forest. Also in the Yay Thoe estuary the dominating species were *R. apiculata* and *C. decandra* (22.9% and 22.9%; 42.9% and 21.4%, for T3 and T4, respectively).

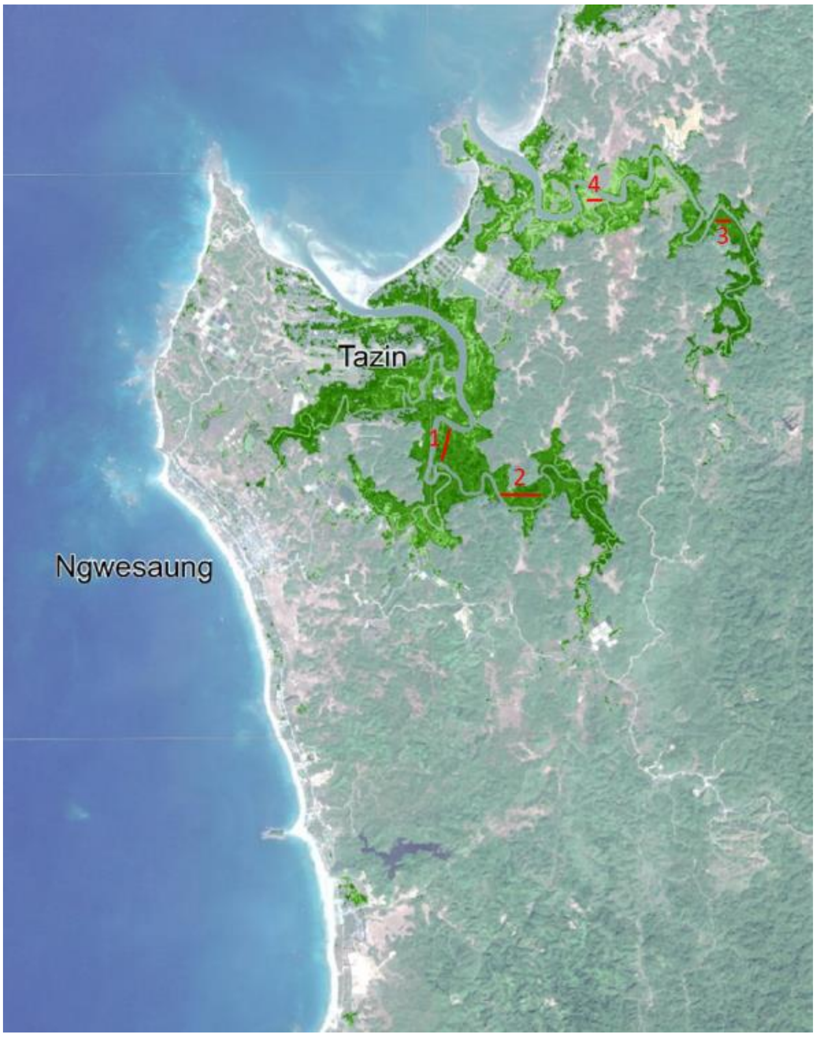


Figure 4.5: Map showing the position in red of the four transects performed in the Ngwe Saung mangroves. Map from FFI Harris *et al.* (2016).

S.

Figure 4.6: Extensive mangrove destruction along transects surveyed in the Tazin (A) and Yay Thoe (B) estuaries.

griffithii was also present in this area, with much less and smaller individuals with respect to Nga Yoke Kaung. In the elevated intertidal area of both estuaries, the endangered species *H. fomes* was present

and common, but nearly all the trees recoded were heavily impacted, showing cut stems and recent regeneration.

Table 4.4: The forestry and ecological parameters recorded in the four transects performed at Ngwe Saung mangroves. N/A-missing data.

Ngwe Saung	T1	T2	T3	T4
Number of tree species	11	7	8	6
Mean height (m)		3.3	2.8	2.3
Total forest density (trees 0.1 ha^{-1})	129.8	214.9	327.6	290.5
Total basal area (m^2 0.1ha^{-1})		0.1	0.5	2
Complexity Index		4.3	3.7	8.2
Degradation Index	2.2	2.1	2.1	1.1
Mean salinity (± St. Dev.)	30.0 ± 0	30.0 ± 0	28.7 ± 1.1	34.3 ± 4.8
No. of juveniles (± St. Dev.)	4.8 ± 5.2	8.0 ± 13.2	4.7 ± 8.9	3.0 ± 3.8

4.3.3 2019 Mangrove Surveys

Two mangrove sites were surveyed around Ma Gyi, Ma Gyi Creek and U To Creek (Figure 4.7). Eight species of true mangroves were recorded (Table 4.5). At all sites, many areas were dominated by *Rhizophora mucronata, Rhizophora apiculata* and *Xylocarpus granatum*.

Figure 4.7 Mangroves surveyed in 2019. Left circle, Ma Gyi Creek; Right circle, U To Creek.

Table 4.5: True mangrove species found at two sites on the Mawtin Coast, Myanmar.

U To Creek	Ma Gyi Creek
Rhizophora mucronata	*Bruguiera gymnorhiza*
Lumnitzra littorea	*Avicennia alba*
Bruguiera gymnorhiza	*Rhizophora apiculata*
Xylocarpus granatum	*Ceriop tagal*
Rhizophora apiculata	*Lumnitzera littorea*
Ceriops tagal	*Sonneratia alba*
Avicennia officinalis	

i Mangroves of U To Creek

Five transects were surveyed in the mangroves of U To Creek. Two of them were selected in the downstream area of the estuary, two of them in the intermediate area and one in the upstream area. At all transects canopy index, average height, average minimum height, average maximum and minimum circumference at breast height, tree density and total basal area were calculated. A maximum canopy index of 8.5 was recorded on transect 5 for *Avicennia officinalis* and *Lumnitzra littorea* on transect 2*.* The minimum CI was 3.5 for *Ceriops tagal* in transect 5. The maximum height of trees was 6m recorded for *Rhizophora mucronata, Lumnitzra littorea* and *Avicennia officinalis* (Table 4.6).

In general A. *officinalis* and R. *mucronata* were generally the tallest in the area, while *Xylocarpus granatum* was extremely dense, up to 1000 trees per hectare, and covered entire islands in the area, and dominated the canopy,

Table 4.6: Vegetation Characteristics of U To Creek Mangroves (CBH=circumference at breast height, 130cm).

Tr No	Plant name	Canopy Index	Mean max Height (m)	Mean min Height (m)	Mean max CBH (cm)	Mean CBH min GBH (cm)	Density No/ha	Total Basal Area (m^2 $0.1ha^{-1}$)
1	*Rhizophora mucronata*	4.8±3.2	6	4.1	58	29	200	0.75
2	*Lumnitzra littorea*	*8.5±7.3*	6	4.6	47	30	500	
3	*Bruguiera gymnorhiza*	*5.2±4.1*	4.2	4	36	31	200	0.35
3	*Rhizophora apiculata*	*5.5±4.2*	5.2	3.5	32	24	100	
3	*Xylocarpus granatum*	*4.2±3.5*	4.5	4	25	2	300	
4	*Xylocarpus granatum*	*4.8±3.8*	5.5	4	71	12	1000	1.2
4	*Bruguiera gymnorhiza*	*6.2±5.3*	4.5	4	17	14	500	
4	*Rhizophora apiculata*	*5.2±3.8*	5.5	4	20	15	600	1.6
5	*Ceriops tagal*	*3.5±2.8*			17	14	100	
5	*Bruguiera gymnorhiza*	*5.8±4.6*	4.5	4	24	23	200	
5	*Rhizophora apiculata*	*5.6±4.2*	5	4	30	16	200	
5	*Avicennia officinalis*	*8.5±6.3*	6	4	63	30	400	7.8

ii Mangroves of Ma Gyi Creek

Bruguiera gymnorhiza had the highest canopy index in Transect 4 (Table 4.7). We recorded a maximum height of 9m for *Avicennia officinalis* in the fringe area of the creek and also high densities of *Rhizophora apiculata, Xylocarpus granatum and Lumnitzra littorea*. The highest basal area calculated was for transect 5 for *Ceriops tagal, B.gymnorhiza, Rhizophora apiculata* and *A.officinalis*. Note that transect 3, chosen at random, had no vegetation.

For both sites, the densities of regeneration and recruitment classes were fairly high, in particular for *Xylocarpus granatum*. Single trees of *R. mucrunata, R. apiculata* and *X. granutum* produces thousands of seeds. The seeds are deposited along the creek banks and mudflats by wave action and wind. In the present study area, they also enter adjoining land along with water during high tides. Most of these seeds are not washed away with the retreating tide as they get entangled in the preexisting vegetation in the area and germinate profusely. The environment is also favourable due to many abiotic and biotic factors such as favorable seed dispersal, availability of limiting nutrients, an absence of folivores, biofoulers and borers and an absence of grazing pressure. At both sites, the density of regeneration and the number of recruitment classes is higher in the lower intertidal zone and decreases towards the higher intertidal zone.

Table 4.7: Vegetation characteristics of Ma Gyi Creek mangroves (CBH=circumference at breast height, 130cm).

Tr No	Plant name	Canopy Index	Mean max Height (m)	Mean min Height (m)	Mean max CBH (cm)	Mean CBH min GBH (cm)	Density No/ha	Total Basal Area ($m^2 0.1 ha^{-1}$)
1	*Rhizophora mucronata*	4.8±3.2	6	4.1	58	29	200	0.75
	Bruguiera gymnorhiza	5.3±3.8	7	4.5	35	26	400	
	Ceriops tagal	4.2±3.5	7	5	22	12	420	
2	*Lumnitzra littorea*	*7.2±6.3*	6.5	5.2	49	38	600	0.35
	Rhizophora apiculata	*5.2±4.1*	4.2	4	36	31	200	
	Rhizophora apiculata	*5.5±4.2*	5.2	3.5	32	24	100	1.4
	Xylocarpus granatum	*4.8±3.5*	4.8	3.8	32	8	450	
3	*No vegetation recorded*							
4	*Xylocarpus granatum*	*4.1±3.8*	6.5	4.8	88	32	680	
	Bruguiera gymnorhiza	*8.8±7*	6.6	5.2	24	18	420	
	Rhizophora apiculata	*5.9±4.2*	5.8	3.8	44	28	600	2.2
5	*Ceriops tagal*	*4.8±3*	7.2	5.2	58	18	200	
	Bruguiera gymnorhiza	*4.4±3.2*	3.8	4	60	42	300	
	Rhizophora apiculata	*5.2±3.8*	4	3.2	35	25	400	
	Avicennia officinalis	*10.5±6.8*	9	6	70	40	600	8.6

4.4 Discussion

4.4.1 Habitat classification

Most areas of mangroves and dry forest are threatened by logging, conversion into plantations and cutting for charcoal production (Figure 4.8). Apart from one area near Nga Yoke Kaung, most of the mangrove areas were small and heavily impacted. In the Ayeyarwady Delta, illegal firewood collection in the area was observed. Law enforcement appears marginal and has little effect. The constant and continuing cutting of branches has left the remaining mangroves in a poor state.

Figure 4.8: Small scale charcoal production is widespread in coastal dry forest areas. Photo C. Zöckler.

4.4.2 2018

i Species composition, vegetation community, degradation level and threats

We recorded twenty-five species of true mangroves, four of which are listed as Nearly Threatened, Endangered or Critically Endangered, and five mangrove associated species.

What remains of the mangrove forests around Nga Yoke Kaung and Ngwe Saung shows that these communities were once very diverse. We recorded a high number of species, but in many cases these were represented by single adult trees, or regenerated trees showing strong impact, such as cut stems. The notable presence of a number of Nearly Threatened, Endangered and one Critically Endangered species, together with the record of two very uncommonly documented mangrove–associated species, show that once these communities were rich and healthy. The current status is highly degraded.

At all sites, the mangroves were deeply impacted, with almost all trees recorded represented by either young specimens or trees recovering from major cut. The mangrove area of Yay Thoe estuary is virtually non-existent, with a very scarce probability of return to a healthy and functional forest. Some ecological functions and services commonly provided by healthy mangrove forests are already gone. At many sites along the transects, soil erosion was clearly visible, in the large gaps formed by heavy cutting (Figure 4.9). In these areas, ecological functions such as soil retention and habitat provisioning for invertebrate fauna were gone, with very little probability of restoration without extensive intervention and replanting.

The degradation of the mature mangrove communities has led to the rapid colonisation of vines and mangrove associated species. In particular, the vine *F. obovata* forms very dense associations that

prevent the recolonization of those area by the propagules of *Rhizophora* spp., *Bruguiera* spp. and *Ceriops* spp., changing the overall ecological balance of the forest. This vine is also growing on the few mature remaining trees, strangling them and shading their leaves.

Human exploitation seems to target selected species at both sites. All species of the genera *Rhizophora* and *Bruguiera*, as well as *Xylocarpus granatum* show major damage. These species are known to provide the best timber and firewood among the mangrove trees and are heavily exploited throughout the tropics (Dahdouh-Guebas *et al.*, 2006, and Figure 4.10(a)). *Ceriops* spp., *Sonneratia* spp. and *N. fruticans* are still impacted, but at a lower level with respect to the previous ones. The former two are used for firewood and charcoal production along the Indo-Pacific coasts, while the latter is known to be utilised for the production of the locally common large roof thatch (Figure 4.10 (b), (c)). On the other hand, all the species belonging to the genus *Avicennia* and *Excoacaria* are rarely cut or destroyed and, since they colonise together specific areas with abundant freshwater and sandy soil, those areas look really healthy and pristine. *Avicennia* spp. wood is not the best option for construction, but it is widely used for charcoal production in all East Africa. It is not easy to understand at this stage why these trees were relatively untouched on the sites visited. *E. agallocha*, when cut, exudes a latex which is mildly toxic and it is never the preferred option for the foresters.
At this stage, it was not practicable to design a monitoring plan for the surveyed areas, although we used photopoints for future comparisons. The anthropogenic pressure on the mangrove sites we surveyed along the Mawtin coast was high and the degree of degradation and destruction were extensive, so there is little forest to monitor. Areas surveyed need management intervention and monitoring could be introduced when such initiatives take place.

In Nga Yoke Kaung we did not observe any change in the general hydrology of the mangrove areas. There were no ditches or dams, as well as very few evidence of industrial pollution. Thus, in that site, the source of mangrove destruction is the extraction of mangrove material for building purposes, firewood and charcoal production performed by local communities. In Ngwe Saung, extraction of mangrove wood and leaves for building and household purposes is surely a major threat to mangroves, as well. However, a large portion of this site had been dammed for extensive crab aquaculture and its overall hydrology is also compromised. This situation represents a serious threat for the whole estuary.

Figure 4.9: (a) Soil erosion, and (b) large gaps of dry soil are clearly visible at Nga Yoke Kaung and Yay Thoe, respectively. Photos S. Cannicci.

Figure 4.10: Extraction of mangrove material: (a) poles of *R. apiculata* for ship and household building; (b) leaves of *N. fruticans* for preparation of roof thatch (c). Photos S, Cannicci.

Community management initiatives are needed as are happening in other regions, such as Rakhine and Myeik. Further study on restoration and rehabilitation of mangroves is also needed, and a Small Grant for 2018-19 has been awarded to fund a study to look at the structure and ecological function of a restored and managed mangrove area near the University of Pathein's Field Station at Ma Gyi.

4.4.3 2019

i Degradation

The degradation of the mature mangrove communities has led to the rapid colonisation of creepers and mangrove associated species. In particular, the vine *F. obovata* forms very dense associations that prevent the recolonization of those areas by the propagules of *Rhizophora* spp., *Bruguiera* spp. and *Ceriops* spp. Anthropogenic activities were also disturbing in this area especially for the genera *Rhizophora* and *Bruguiera*, as well *Xylocarpus granatum* showing major damage. On the other hand, species belonging to the genus *Avicennia* are rarely cut or destroyed and, since they colonise together specific areas with abundant freshwater and sandy soil, those areas look really healthy and pristine.

Mangrove restoration area, University of Pathein project, near Shwethaungyan.

CHAPTER 5. HABITAT MAPPING

Authors: Maylene Loo, David Miller and Sue Murray-Jones

5.1 Introduction

Due to the long wet season and the proximity to the Ayeyarwady River Delta, visibility is often poor on the Mawtin Coast. Many habitats, such as coral and seagrass, are found in fairly shallow water, making SCUBA surveys difficult in anything but completely calm conditions. Hence we decided to use remote survey methods, which have many advantages. They are suited to the difficult conditions of the area, and provide a safer approach as well as permitting larger scale subtidal surveys. Video imagery can be analysed qualitatively and quantitatively, and can be archived for future research.

The key biodiversity areas of interest for the Capacity Building for Coastal Biodiversity Assessment Partnership were determined from work conducted in 2016 and early 2017 to be around the following areas: Gwa; Ma Gyi and Pho Htaung Bay; Ngwe Saung (in particular the offshore Bird Islands-see map, Figure 5.1); and Nya Yoke Kaung.

David Miller, Senior Research Officer for the Marine Parks Project, Department of Environment, Water and Natural Resources, South Australia, ran the 2018 training and field work, while Dr Maylene Loo, Maytrix Solutions, ran the 2019 habitat mapping. The survey focused on the collection of video footage to identify the benthic habitats present, with occasional ground-truthing via snorkel.

Habitat mapping was undertaken for the key biodiversity areas identified around Nya Yoke Kaung, the Bird Islands, White Sand Island off Chaung Tha, Ma Gyi, Wetthe, Pho Htaung Gyiang and Poe Laung (Figure 5.1).

There is little habitat information available for the Mawtin coast, other than the data collected as part of Phase I and Phase II of this partnership, summarized in previous chapters. Satellite imagery is of limited use in this area due to poor water clarity because of its proximity to the Ayeyarwady Delta, and attempts to use drone imagery to delineate habitats have not been particularly successful (Murray-Jones *et al.* 2017). Hence the move to collect data on a broader scale than diving transects, by using an underwater towed video array.

Some habitat mapping was also conducted around the Myeik Archipelago in 2020, but the results have not been included here.

5.2 Method

Field training and data acquisition were carried out around in January 2018 around White Sand Island near Chaung Tha, the Bird Islands off Ngwe Saung and around Nya Yoke Kaung (Figure 5.1a), and in 2019 (Figure 5.1b).

Figure 5.1: Map of areas targeted for habitat mapping in (a) 2018 and (b) 2019. Google Maps.

5.2.1 Data collection

A Scilex 0.05 Lux camera with a Scilex NMEA video and audio encoder were used, in conjunction with a Lawmate PV-1000 Touch hard-drive/video recorder. An appropriate camera frame (Figure 5.2) was constructed in Australia. All data were collected during field training.

Figure 5.2: Camera with cage being deployed.

Video transects were run at speeds between 1-3 knots around islands and headlands (depending on winds and currents), and were generally kept to 20-30 minutes duration. Waypoints and depth were recorded for the beginning and end of each transect on a data sheet, and trainees taught appropriate record keeping. GPS data was simultaneously encoded to the audio track of the videotape to provide position information relative to video footage. Topography varied greatly, especially around Nya Yoke Kaung. Transect locations were determined by wave exposure, wind speed and direction, suitability of boat, available time, previous surveys, and the recommendations of the boat driver.

GPS data from the NMEA audio encoder were decoded using the program Visual GPSView, and saved in an Excel worksheet. GPS data were filtered so that every 10^{th} GPS point was assessed for habitat (a distance of approximately every 10 m on the ground). Benthic habitat data were extracted from video footage manually using categories decided by the trainees with input from the consultants (Appendix 3). In general, if the habitat made up <30% of the frame, it was not included in the categorization.

Due to the complex of subtidal and intertidal reef and sand flat habitats at Ma Gyi, transects were carried out where possible, otherwise, point sampling was used, in as close to a grid system as possible, where the camera was dropped, and a short video taken. During processing, three random screen grabs were categorized.

We used the definitions in Appendix 3: Categories for habitat mapping, which were generally the same for both years, with the addition of seagrass in 2019. Only categories that had a higher than 30% cover were scored. Note that while all data were retained and archived, the above categories were collapsed into the following colours for mapping:

- ≥50% coral—blue
- Predominantly sand—yellow
- Predominantly rock—red
- Predominantly rubble—black.

These habitat types derived from video data were used to create information layers in publicly accessible GIS software (QGIS 2.18 in 2018, and QGIS 3.4 in 2019). These were then used in combination with available imagery to produce habitat maps for all transects.

Constraints associated with availability of university personnel and the international consultant, vessel suitability, and prevailing weather conditions restricted the extent of mapping. The degree of coverage achieved in the available time was less than optimal for creating maps. Conditions were not always ideal, with strong sea breezes in the afternoons. Some of the boats used were long-tail boats which cannot reverse or stop easily, and there were many high profile reefs, which sometimes snagged the camera. Much of the coral and seagrasses on this coast are in very shallow water, and data were collected from as close as practicable to preselected waypoints in the prevailing conditions. In shallow water, the boat would navigate around bommies, despite our requests to go straight, rather than allowing us to tow the camera over them, hence coral is very under-represented in the surveys. Depth was recorded at the beginning and end of each transect, and depths ranged between 3 and 6 m in general.

As a result, interpretation and interpolation of information to delineate habitat boundaries was difficult. Habitats were also patchy. We have made no attempt at this stage to delineate boundaries (even if we had suitable ortho-rectified imagery and ground-truthing, we do not have enough data to extrapolate). However, the data collected represents a considerable step forward compared to what was previously known for these areas.

5.3 Results

i White Sand Island

The dominant habitats around White Sand Island were sand and rocky reefs. Some areas of reef supported good coral cover, especially NW of the island (see Figure 5.3), with more sand on the NE side and extensive rubble areas on the SE side. No seagrass was seen on videos, although some was noted in a sheltered area close inshore in 2016.

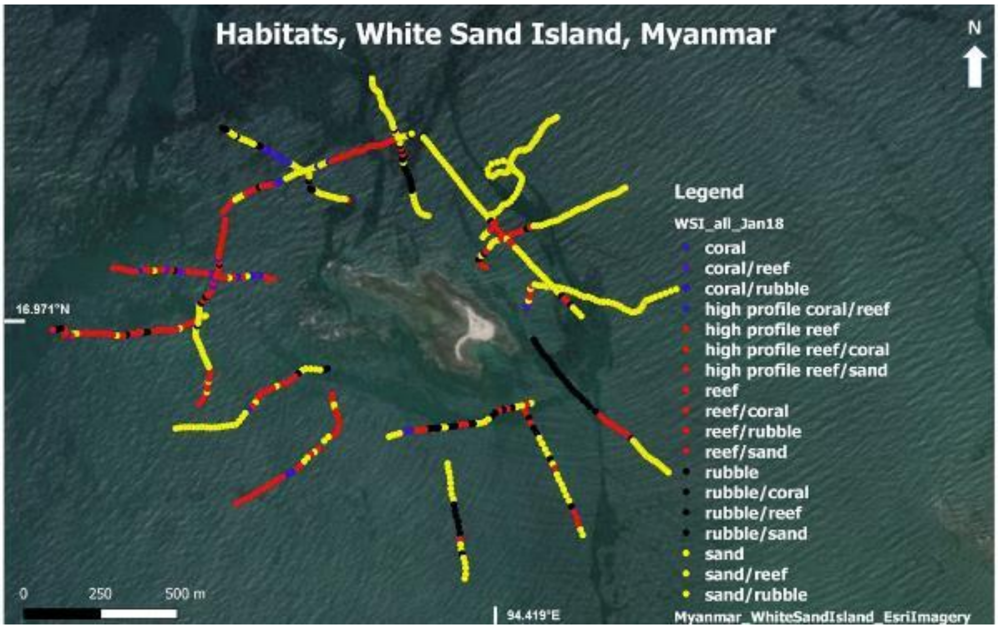


Figure 5.3: Habitat map of White Sand Island, Myanmar showing categorised data from video tows in January 2018.

ii Bird Islands

North Bird Island

North Bird I has extensive coral on the more sheltered side, with sand on the mainland side of the coral (Figure 5.4), and some areas of nearly 100% cover (Figure 5.5). Much of the underlying substrate around the island is rocky reef, and no seagrass was found at either of the North or South Bird Island.

South Bird Island

Data points were a little more widely spaced around South Bird I due to some issues with the system. Trainees required more practice using the camera system and survey coverage was reduced at this site. Much of the data had to be manually extracted from video files, and some was unable to be extracted. There were areas of good coral interspersed with rock and sand patches, and extensive reef and large boulder fields to the south and west sides (Figure 5.4).

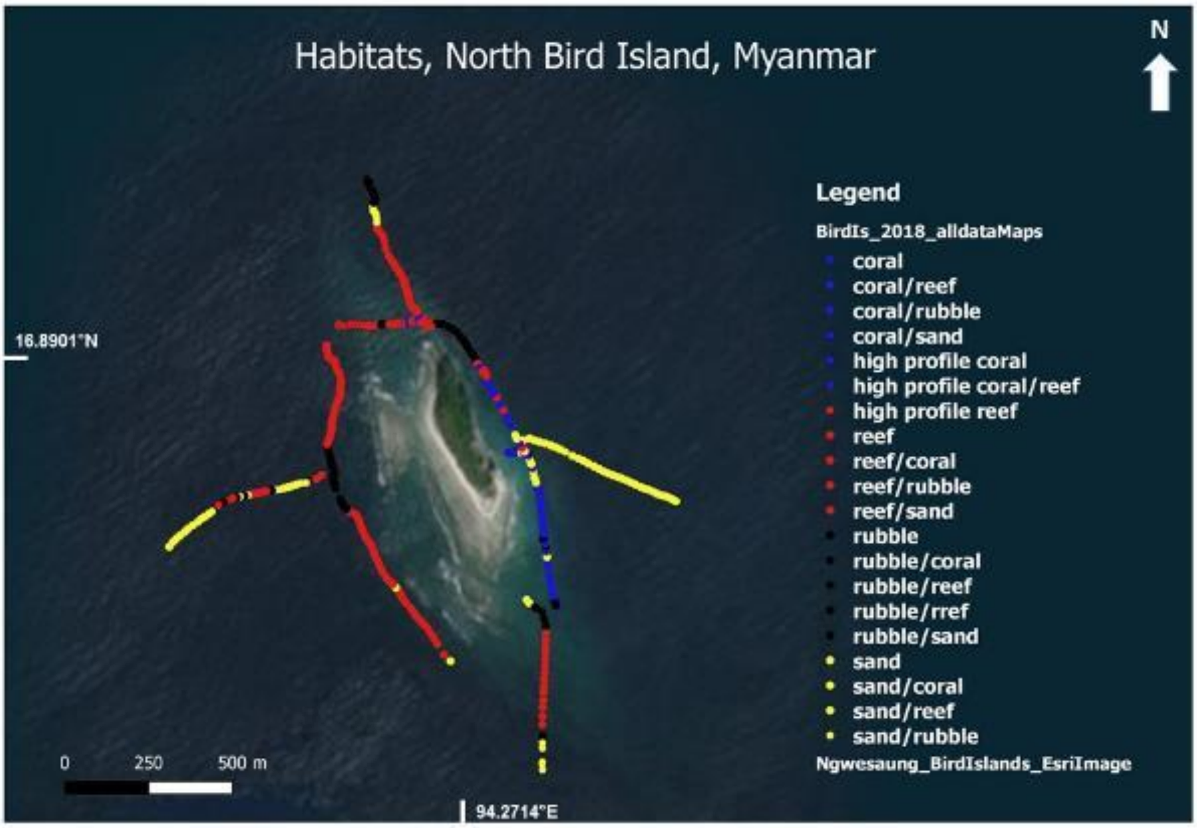


Figure 5.4: Habitat map of North Bird I, Myanmar showing categorised data from video tows in January 2018.

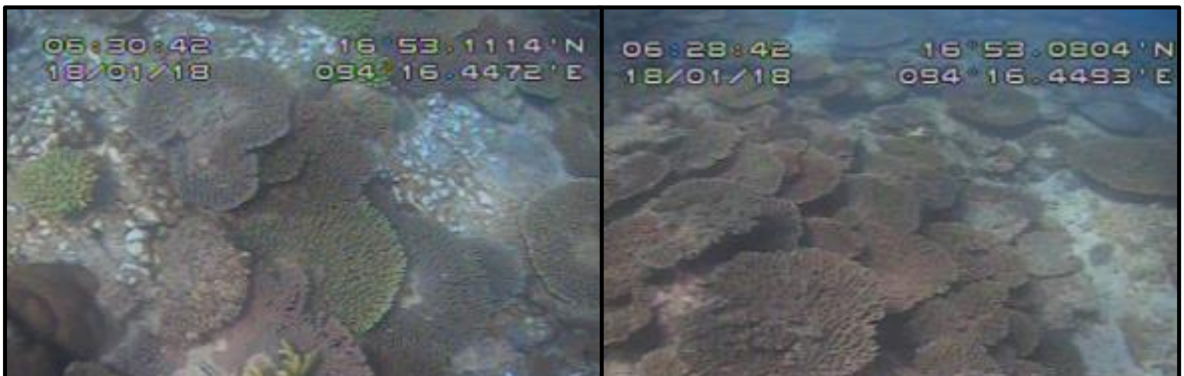


Figure 5.5: Screenshots of coral habitats from Silex camera, North Bird I, Myanmar.

Figure 5.4: Habitat map of South Bird I, Myanmar, showing categorised data from video tows in January 2018.

iii Nya Yoke Kaung

To the north of Nya Yoke Kaung, habitats were mainly sand and rocky reef, although there were some areas of good coral on areas exposed to currents but sheltered from storms (Figure 5.5, Figure 5.6). To the south, almost no coral was present, with muddy sand and rocky reef predominant (Figure 5.7). No seagrass was seen on any video tows in Nya Yoke Kaung.

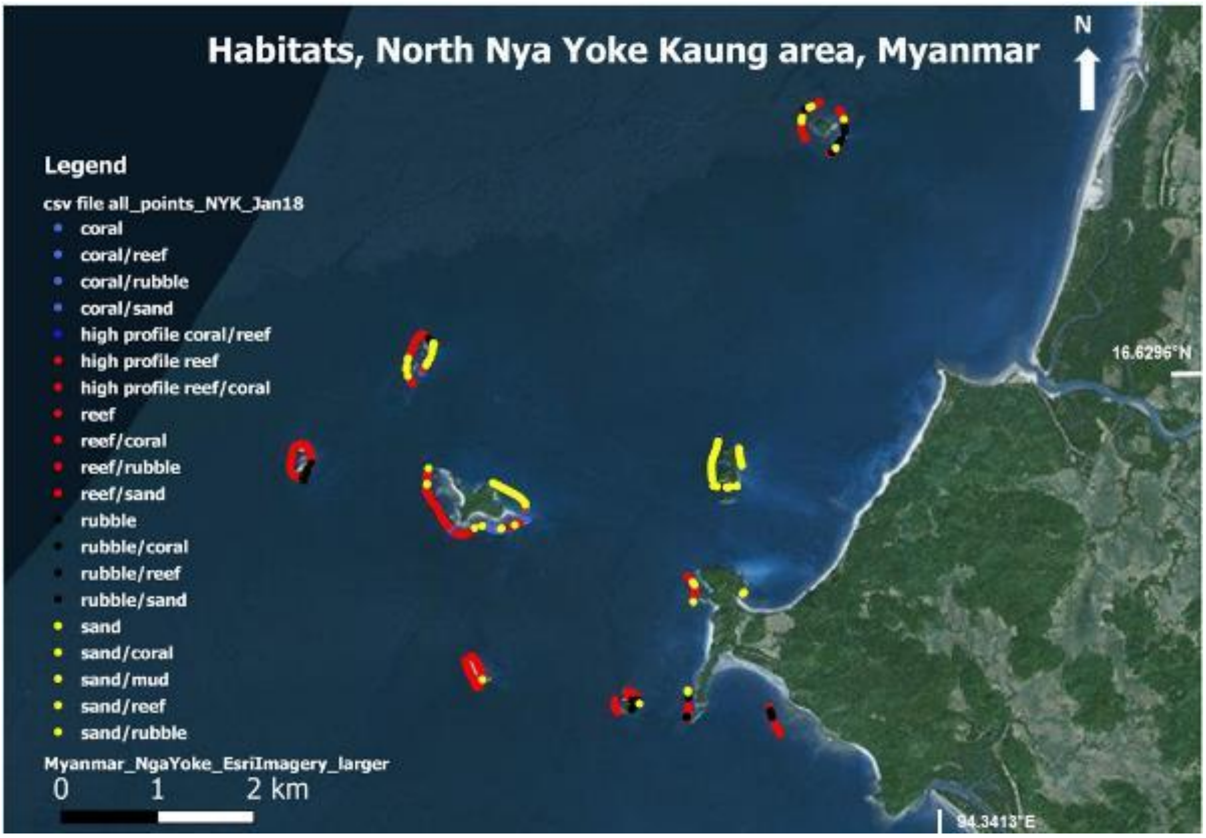


Figure 5.5: Habitat map of North Nya Yoke Kaung area, Myanmar, showing categorised data from video tows in January 2018.

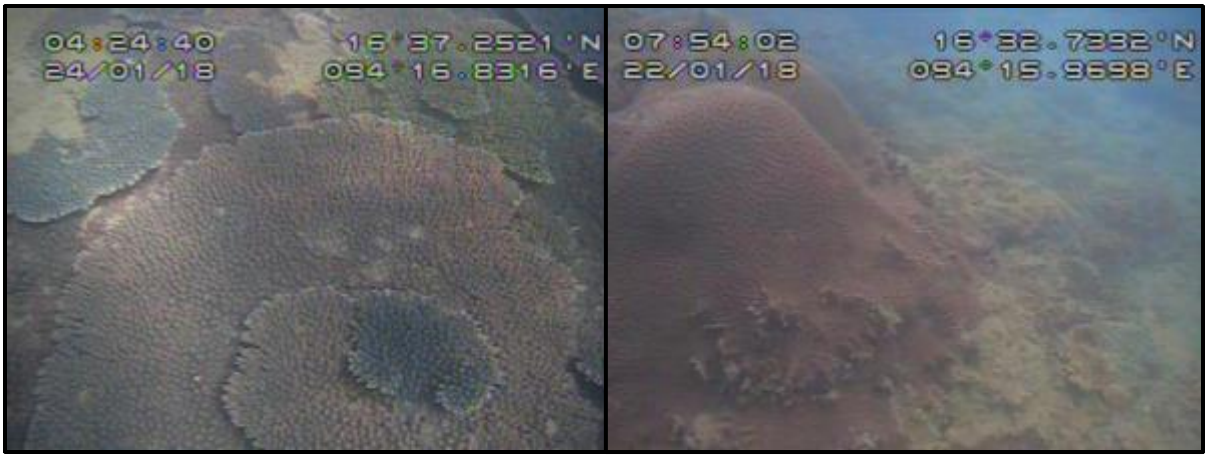


Figure 5.6: Screenshots of coral habitats from Silex camera, Nya Yoke Kaung area, Myanmar.

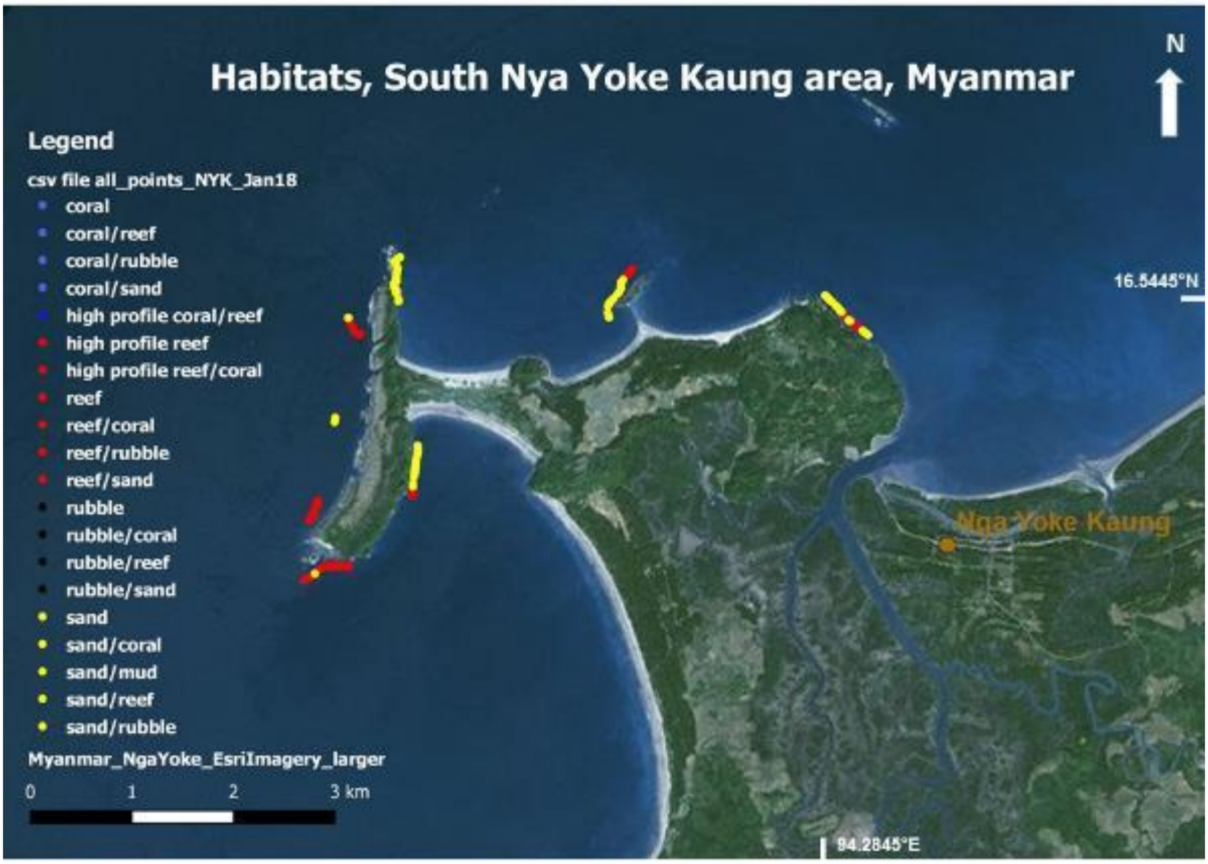


Figure 5.7: Habitat map of South Nya Yoke Kaung area, Myanmar, showing categorised data from video tows in January 2018.

iv Poe Laung

Transect depths in the Poe Laung area ranged from 5.1 to 20.5 feet (1.6 to 6.2 m). The dominant habitats in this area were mostly sand except for the western and northern transects (Figure 5.8). The northern transect showed dense and sparse corals interspersed among sand and rubble while the western transect had some corals on predominantly rocky substrate, with medium cover of seagrasses recorded only on one transect (Figure 5.9).

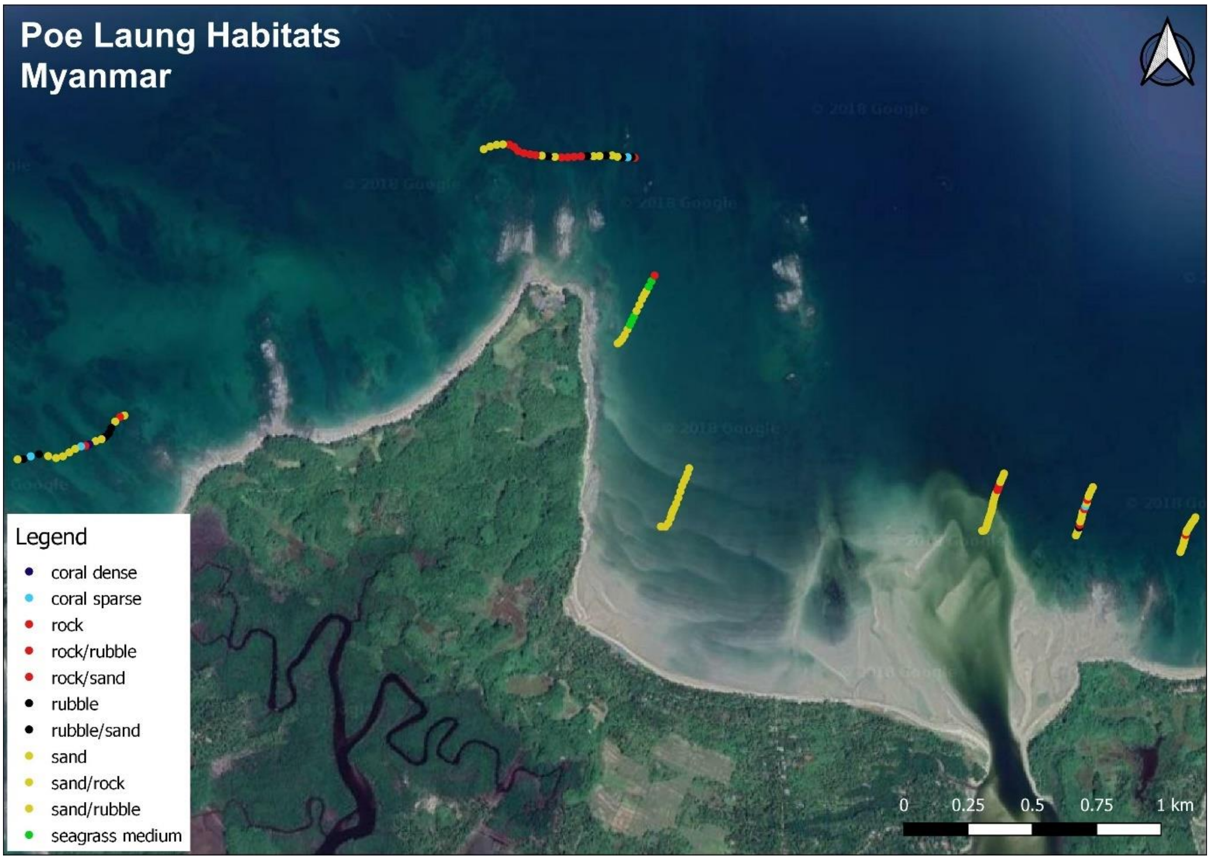


Figure 5.8: Habitat map of Poe Laung area, Myanmar, showing categorised data from video transects in January 2019.

Figure 5.9: Screen shots of coral and seagrass habitats recorded in Poe Laung area, Myanmar.

v Pho Htaung

The sites around the Pho Htaung area were generally shallow with depths less than 10 feet (3 m). The habitats were dominated by seagrasses with dense cover recorded on four of the eight transects (Figure 5.10). Rubble substrate was recorded on the northern transect and some algae were also recorded on one transect.

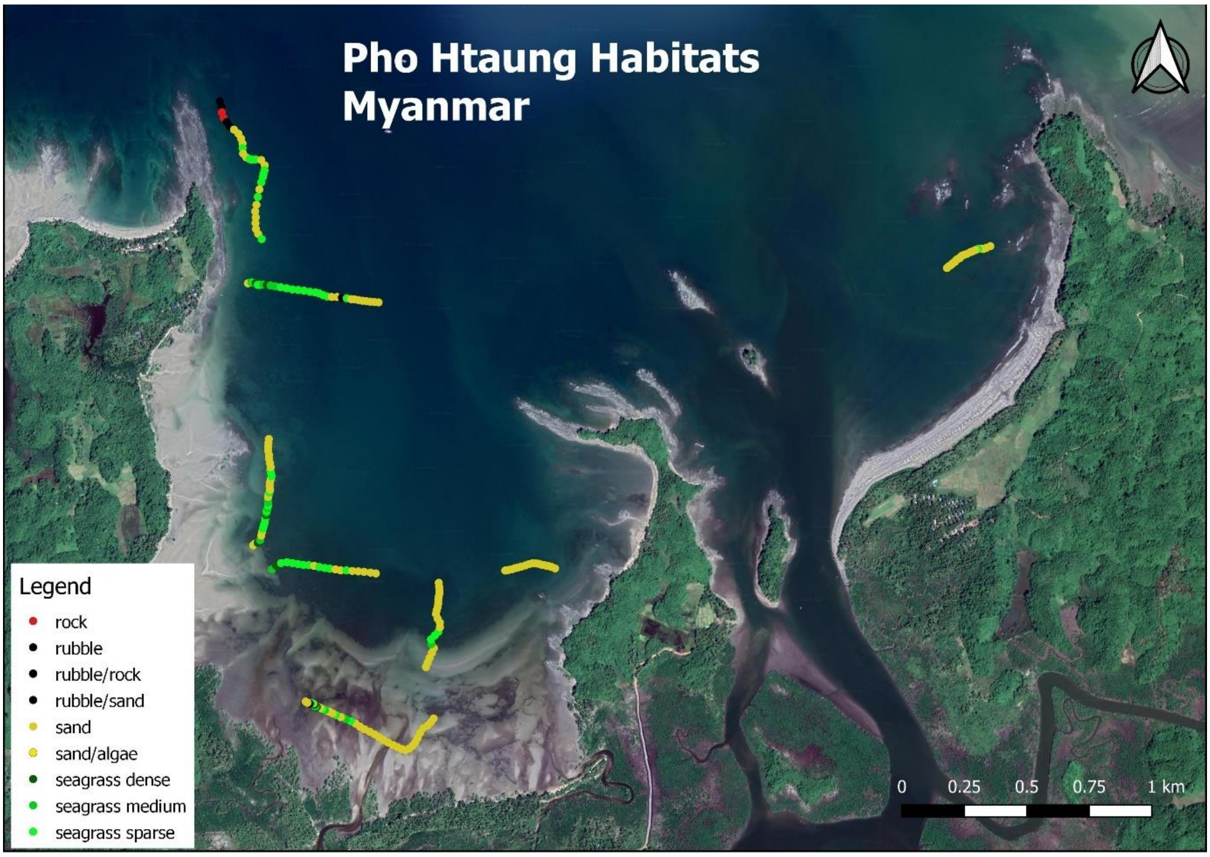


Figure 5.10: Habitat map of Pho Htaung area, Myanmar, showing categorised data from video transects in January 2019.

vi Wetthe

Transect depths in the Wetthe area ranged from 6.5 to 21.5 feet (2 to 6.5 m). The habitats were mostly sand except for the western transect which had sparse and medium coral on a rocky substrate (Figure 5.11). Seagrasses were found on the shallower transects with the transect running horizontal to the shore showing extensive cover of sea pens.

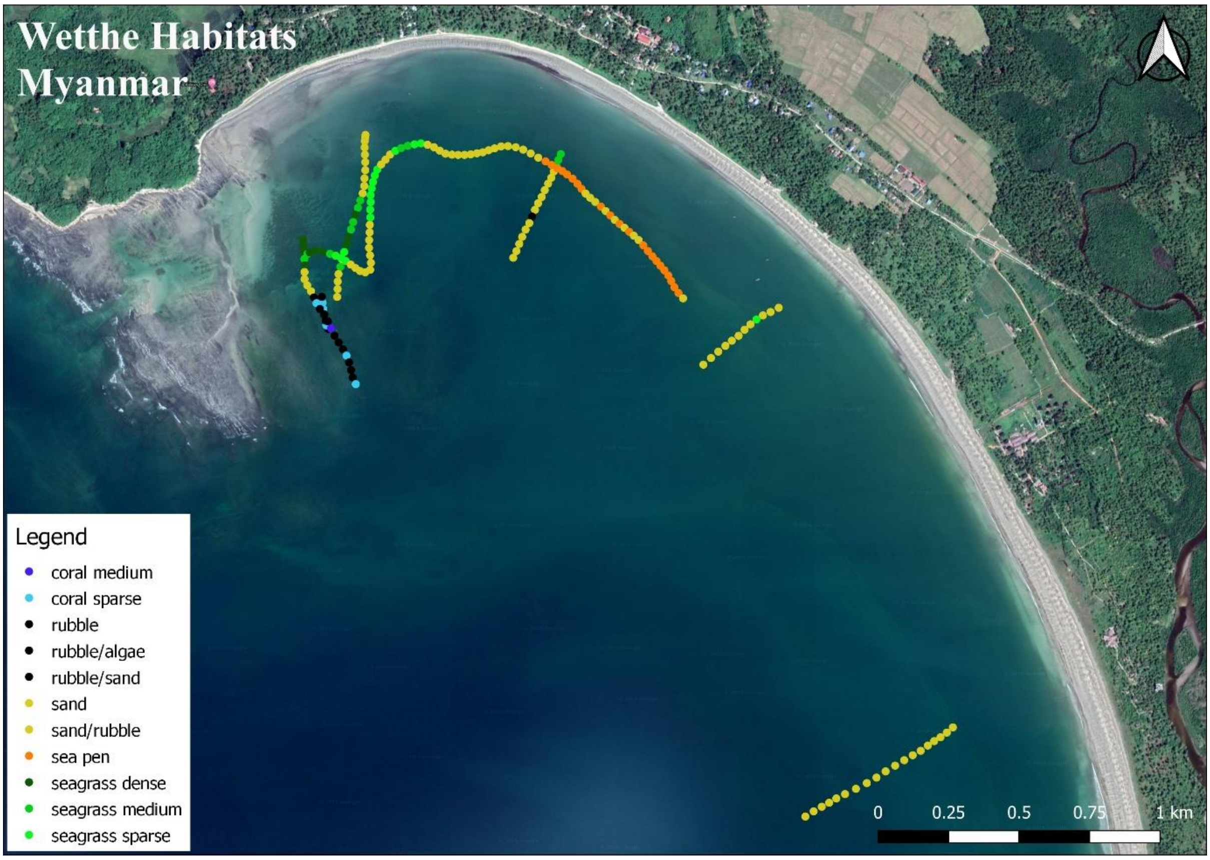


Figure 5.11: Habitat map of Wetthe area, Myanmar, showing categorised data from video transects in January 2019.

vii Ma Gyi

The depth of sites sampled in Ma Gyi area ranged from 4.5 to 24.2 feet (1.4 to 7.4 m). Due to the complex reefal substrates, only six transects were recorded (Figure 5.12). The other 14 sites were screen shots from individual camera drops. Video footages from the transects showed very diverse habitat types. The northern transect was mostly rubble/rock, while the middle and southern transects were sand and seagrasses. The transect that went around the island (Kyuak Lon Gyi Kyun) had a diverse habitat of coral and seagrass mixed with rock, sand and rubble. The algae *Padina* sp. was recorded on one of the transect (Figure 5.13). The point sampling yielded variable habitat types, from bare sand to seagrass and coral habitats. Note for the point sampling, three shots were taken at each drop, but have been spread out a little on the map to show the habitats at each of the points.

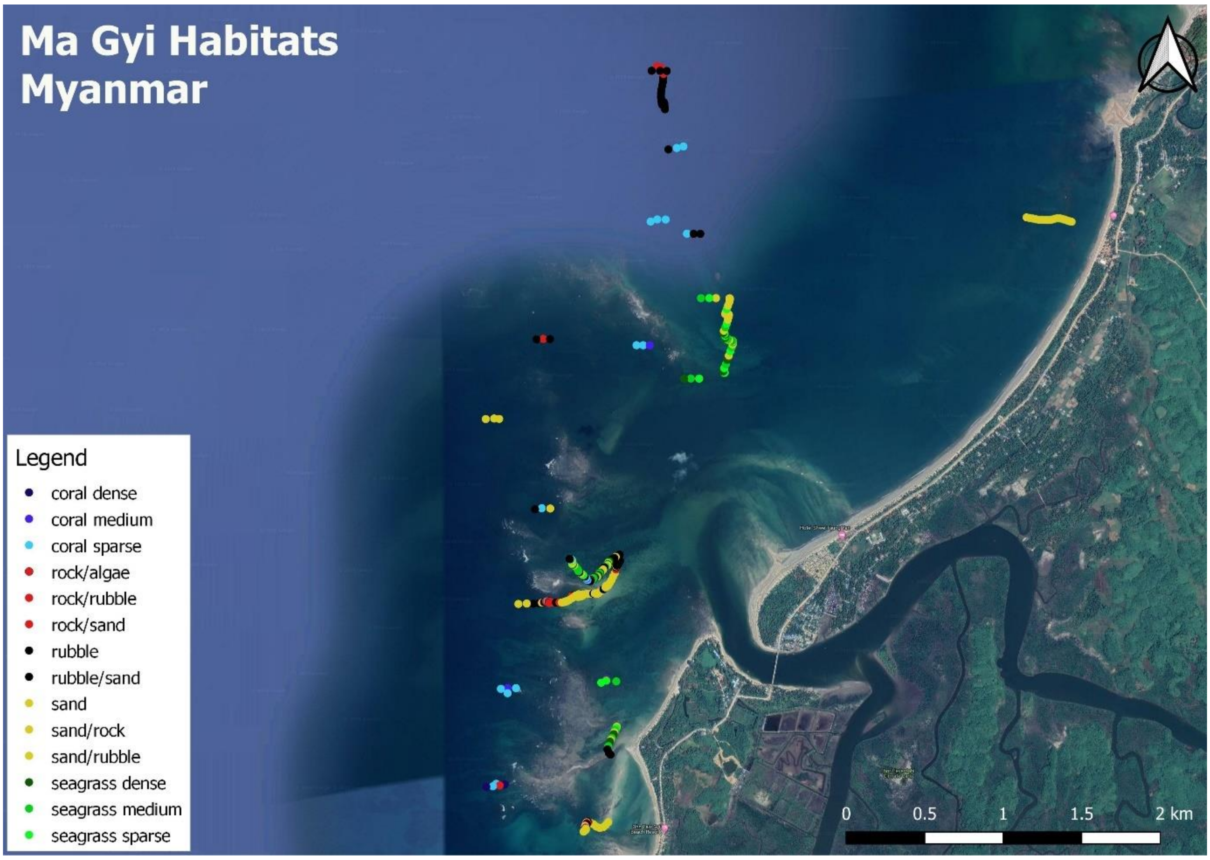


Figure 5.12: Habitat map of Ma Gyi area, Myanmar, showing categorised data from video transects and sampling points in January 2019.

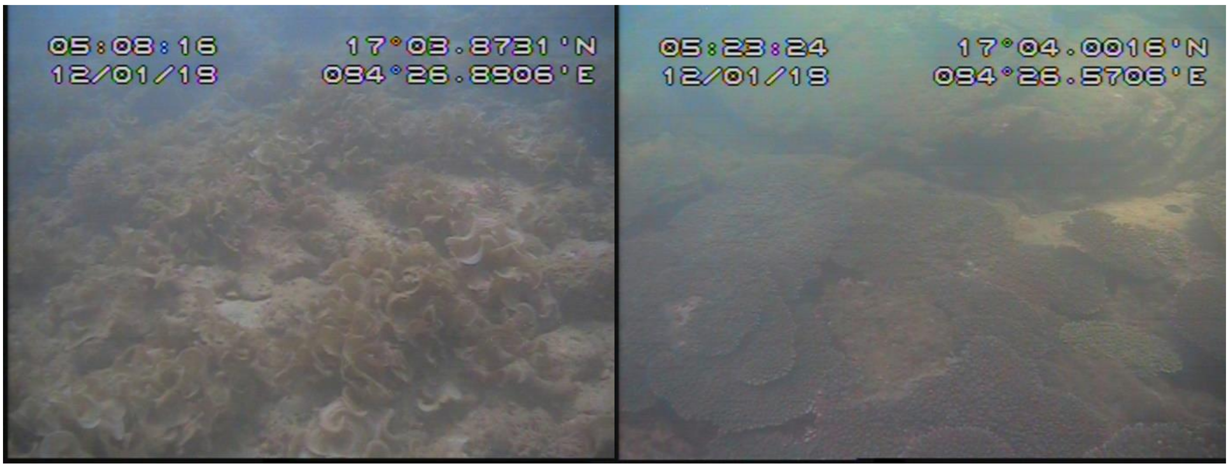


Figure 5.13: Screen shots of algae habitat with *Padina* sp. and habitat recorded in Ma Gyi area, Myanmar.

5.4 Discussion

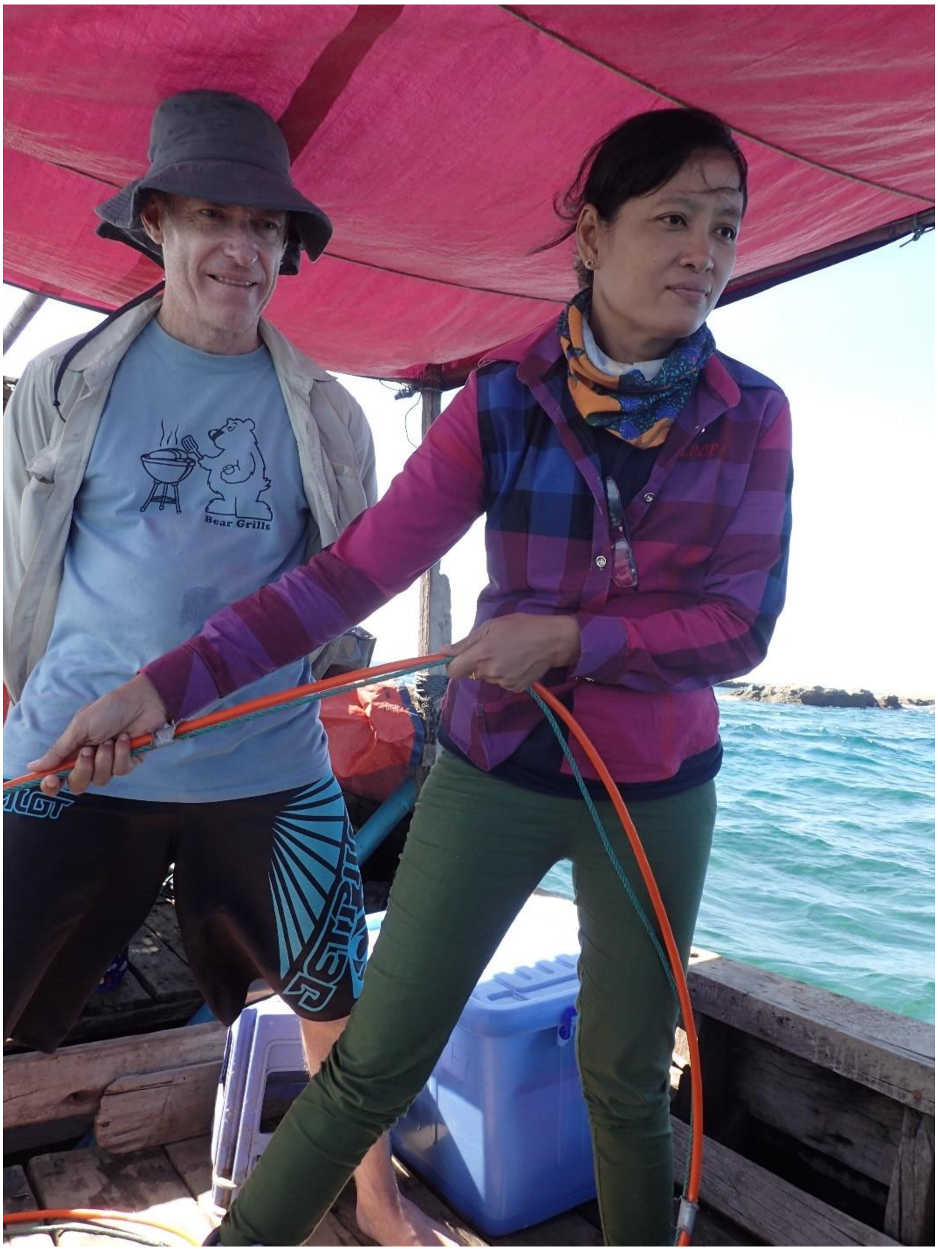
In 2018, there were some teething problems with the equipment, and also with trainees not always using the video system correctly, which lead to gaps in data and missing transect data.

There were some areas with nearly 100% coral, but these were generally restricted to small areas. Much of the coral in good condition was in areas too shallow for boat access (and effectively too shallow for SCUBA, in 2-3m of water, in fairly exposed locations). The exception to this were in the

clearer waters well offshore (the Bird Islands, for example). Particularly noticeable was the lack of fish on nearly all sites.

The degree of coverage achieved in the available time was not sufficient to create full habitat maps. In addition, the lack of aerial photography allied to high turbidity in some of the areas meant that conventional habitat mapping (delineating like areas, and then ground truthing) could not be carried out. As such, the habitat maps are not intended to be definitive; however, they are the first benthic habitat maps for the areas surveyed, and as far as can be ascertained, for the Mawtin coast.

A comprehensive user manual has been produced (Murray-Jones *et al.* 2019) with all steps outlined, accompanied by screenshots, to guide people in the use of the camera, boat safety, deployment in the field, acquiring and decoding data, right though to producing a map in QGIS. This manual provides a useful resource and will be updated as new versions of software become available.



Professor Cherry Aung, Head, Marine Science Department, Pathein University, deploying habitat mapping camera array with trainer David Miller.

CHAPTER 6. BIRD SURVEYS

Authors: Christoph Zöckler and Saw Moses

6.1 Introduction

In February 2016, Christoph Zöckler (ArcCona Consulting) and U Saw Moses (Independent Consultant), with assistance from Daw Ni Lar Pyint (Forestry Department), U Thant Zin Tun (FFI) and Dr. Naing Ye Win (Pathein University) visited selected sites (see Figure 6.1) in the eastern Ayeyarwady Delta and along the Mawtin coast to survey bird populations. A brief characterization of mangrove condition was also included, which was presented in Chapter 4.

The Meinmahla Kyun Wildlife Sanctuary reserve was established in 1993 covering 13,670 ha in size and is under the management of the Forest Department of the MONREC. It comprises an island about 16 miles long and 6 miles wide, covered in mangroves. Surveys of the Wildlife Sanctuary and adjacent Outer Delta Islands in the Ayeyarwady Delta were conducted in December 2016 with U Toe Tat Aung and U Soe Min Hteik, Master of Science students from Pathein University (Fig. 4.1b). The Meinmahla Kyun Wildlife Sanctuary was declared a Ramsar site subsequent to this survey, on February 2, 2017. The reserve has the world's largest population of critically endangered mangrove species, and over 20 species of threatened fauna[5], and is a very rich and diverse migratory bird habitat.

This chapter has been compiled from two reports on the bird survey and training, one written by Christoph Zöckler and Saw Moses[6] (Independent Consultant) for FFI, and the other by Christoph Zöckler[7]. All photos and maps in this chapter provided by C. Zöckler.

6.2 Method

February 2016: The Mawtin Coast from Point Mawtin to the Bay of Mata near the Rakhine border has not been surveyed previously for birds. Boats and motorbikes were used to reach inaccessible sites. Given the time frame, large areas were not surveyed but the main areas of interest such as mangroves, mudflats and selected islands were covered. The total area covered by the survey stretches along the entire coast of the Ayeyarwady Region, almost 200 km (see Figure 6.1a).

This long stretch of coast necessitated a rapid assessment. Sites were selected prior to the survey based on satellite images, indicating mudflat and mangroves or on an *ad hoc* basis while surveying. Constraints of boat access, shallow waters and tide did not always allow access of planned sites. In particular the first mostly rocky stretch was under-surveyed due to initial boat constraints. The time spent at sites varied between several minutes and two hours, depending on tides and access constraints.

Bird records include sightings as well as sound records, and in a very few cases tracks only. Binoculars (8 and 10x 40) as well as three zoom telescopes (15-45x 60) were used in addition to sound recordings with Telinga Parabolic microphones to obtain additional information on more secretive species. All birds were recorded on a daily basis with numbers where possible or useful. Selected bird recordings were also tagged with GPS coordinates and their sightings are displayed in figures 4.2-4.5.

December 2016: The Meinmahla Kyun Wildlife Sanctuary and adjacent Outer Delta Islands in the Ayayarwady Delta were surveyed, using the same methods (Figure 6.1b). This area was previously surveyed by Zockler in January 2010, November 2013 and December 2015.

[5] http://www.mmtimes.com/index.php/national-news/24819-meinmahla-kyun-wildlife-sanctuary-designated-ramsar-site.html, accessed 16/2/17

[6] Christoph Zöckler & Saw Moses (2016). Bird survey report Eastern Delta and Mawtin Coast, Ayeyarwaddy Region, Myanmar 18 – 28 February 2016. Report to FFI, Myanmar.

[7] C. Zöckler (2016) Bird survey and training report Ayeyarwady Delta, Myanmar. 03 - 08 December 2016, Draft report for FFI.

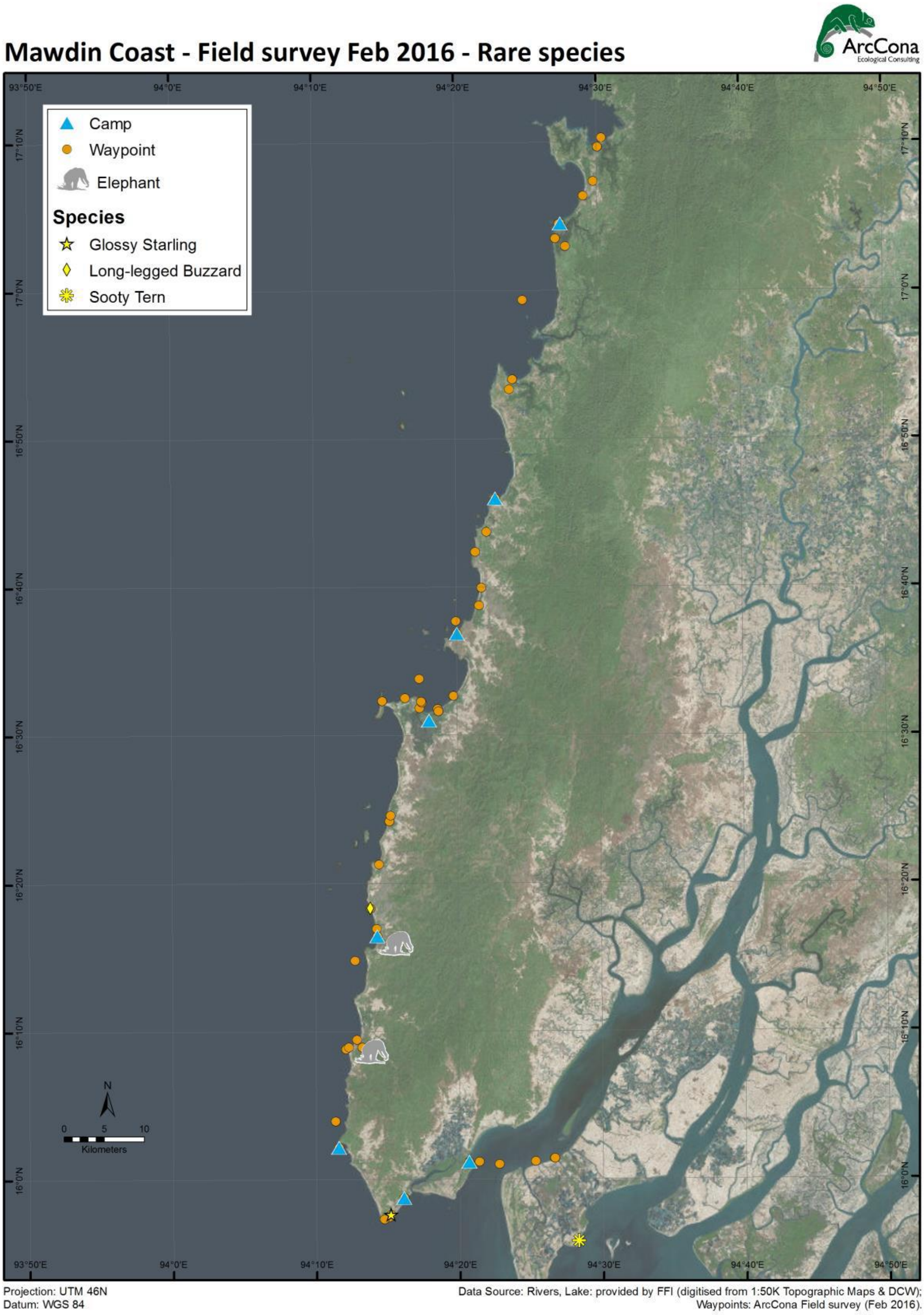


Figure 6.1: (a) Survey area in February 2016 showing survey sites and camp sites; also three rare bird sightings. Major survey sites (labelled as waypoints in the legend) are indicated in orange.

Figure 6.1 (b). The Meinmahla Kyun Wildlife Sanctuary and adjacent Outer Delta Islands in the Ayeyarwady Delta surveyed in December 2016. Survey Points in orange, yellow star marks primary roosting site for globally threatened water bird species.

6.3 Results

6.3.1 Mawtin Coast, February 2016

In total 163 bird species were recorded (see Appendix 4). None of these are listed as globally threatened but seven species are listed by Birdlife International (2015) as near-threatened, of which six were observed only in the eastern delta (see Table 6.1). Waterbirds were scarce. Only Phone Taw Paey Beach held significant numbers of waterbirds. Almost all the near-threatened category birds were observed only there.

A high number (29) of Black-headed Ibis were found near Haingyi. As the area was not easy accessible the actual number could be higher. Both Phone Taw Paey and Haingyi mudflats host large numbers of Black-headed Ibis. One site in the Mata Bay north of Magyi had also high numbers of waterbirds. More than 70 Little Egrets, 12 Redshanks and 12 Terek Sandpiper were noted here. Not all adjacent areas were covered and the total number could be even higher (Figure 6.2).

In general the coast consists of sandy beaches and rocky shores. In parts there are bays with mudflats and mangroves. Islands and rocky outcrops near the coast are also home to areas of dry forest.

Table 6.1: Globally listed species (BirdLife International 2015) observed in the Eastern Ayeyarwady Delta in February 2016. NT=Near Threatened.

Common name	Scientific name	IUCN Category	Number
Darter	*Anhinga melanogaster*	NT	1
Black-headed Ibis	*Threskiornis melanocephalus*	NT	29
Bar-tailed Godwit	*Limosa lapponica*	NT	3
Black-tailed Godwit	*Limosa limosa*	NT	400
Curlew Sandpiper	*Calidris ferruginea*	NT	160
Red-necked Stint	*Calidris ruficollis*	NT	120

i *Sandy Beaches*

Sandy Beaches: There was a high level of disturbance on sandy beaches, due to motorbike traffic and in some areas, coastal development. Wintering Sandplovers, such as Greater and Lesser Sandplovers, Kentish Plover and some Pacific Golden Plovers were using these beaches in less disturbed areas in small numbers (Figure 4.2).

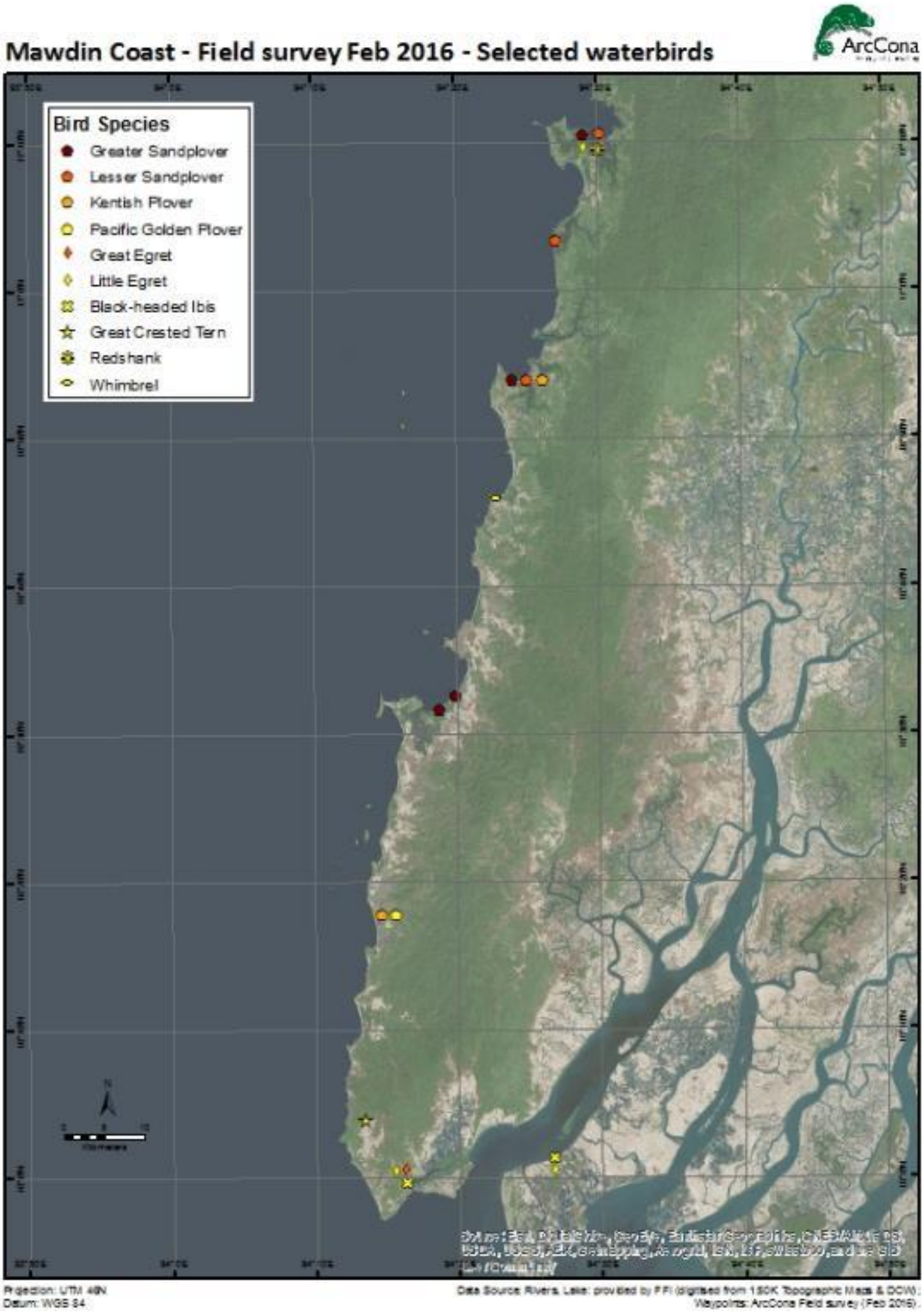


Figure 6.2: Water birds on the Mawtin coast during 2016 surveys(N.B. Phone Taw Pyae has not been included on this map).

ii Mangroves and mudflats

Mangroves and mudflats are co-existing habitats and often adjacent to each other. They exchange water, sediments and also species interacting between them. The mudflat areas were rather small and scarce apart from two sites (see below).

All mangrove areas visited in the survey area have been impacted by human activity in one way or another. The impact varies from almost clear cut to only a few selected trees taken out. The observed mangrove areas along the Mawtin coast varied from Category 2 (see Table 4.1 for categories): heavily impacted; only small scattered trees left to 4: still large and mature trees are available but the impact of cutting are clearly visible, with 3 stages in between (see Figure 6.3).

Apart from the extensive mangrove areas in Nga Yoke Kaung and the Bay of Ma Tha, the coast is not very rich in mangroves and mudflats. Figure 6.3 also depicts the distribution of six bird species typical for mangroves. Hardly any mangrove site visited was without the Collared Kingfisher. White-throated Fantails however, were only observed at two sites. Even though this song bird is quite vocal, it has only been recorded twice on the Mawtin coast. Longer survey periods might reveal a higher density. Black-capped Kingfisher, which prefer mangrove habitats, were not as common as Collared Kingfisher. The Green-billed Malkoha is a common mangrove species in Myanmar but was only observed in the mangroves up north in Pho Htaung Gyaing in Ma Tha Bay.

Mudflats were rare. There were small areas near mangroves, but these rarely held large numbers of waterbirds. Apart from Phone Taw Pyae Beach near Haingyi, there was only one mudflat area, Pho Htaung Gyaing, with had considerable numbers of waterbirds. Here the majority were Little Egrets (>70), Redshank (12), Terek Sandpiper (12), Lesser Sandpiper (>70), Turnstone (8) and Whimbrel (3). None of these waterbird species is globally threatened or were present in significant numbers.

iii Rocky Shores

Rocky coasts and rocky shores intermingled with sandy beaches are widespread and a common feature of the Mawtin coast. They generally had low species diversity. Unexpected and quite widely distributed along the entire coastal stretch was the Blue Rock Thrush, *Monticola solitarius*. The subspecies M. *philippensis* is known from mountain ranges and has been recorded from few sites in Chin State only. To see this subspecies at sea level was unusual. Rocky shores are also home to the Pacific Reef Heron, most of the White-bellied Sea-eagles and the Ruddy Turnstone (Figure 6.4).

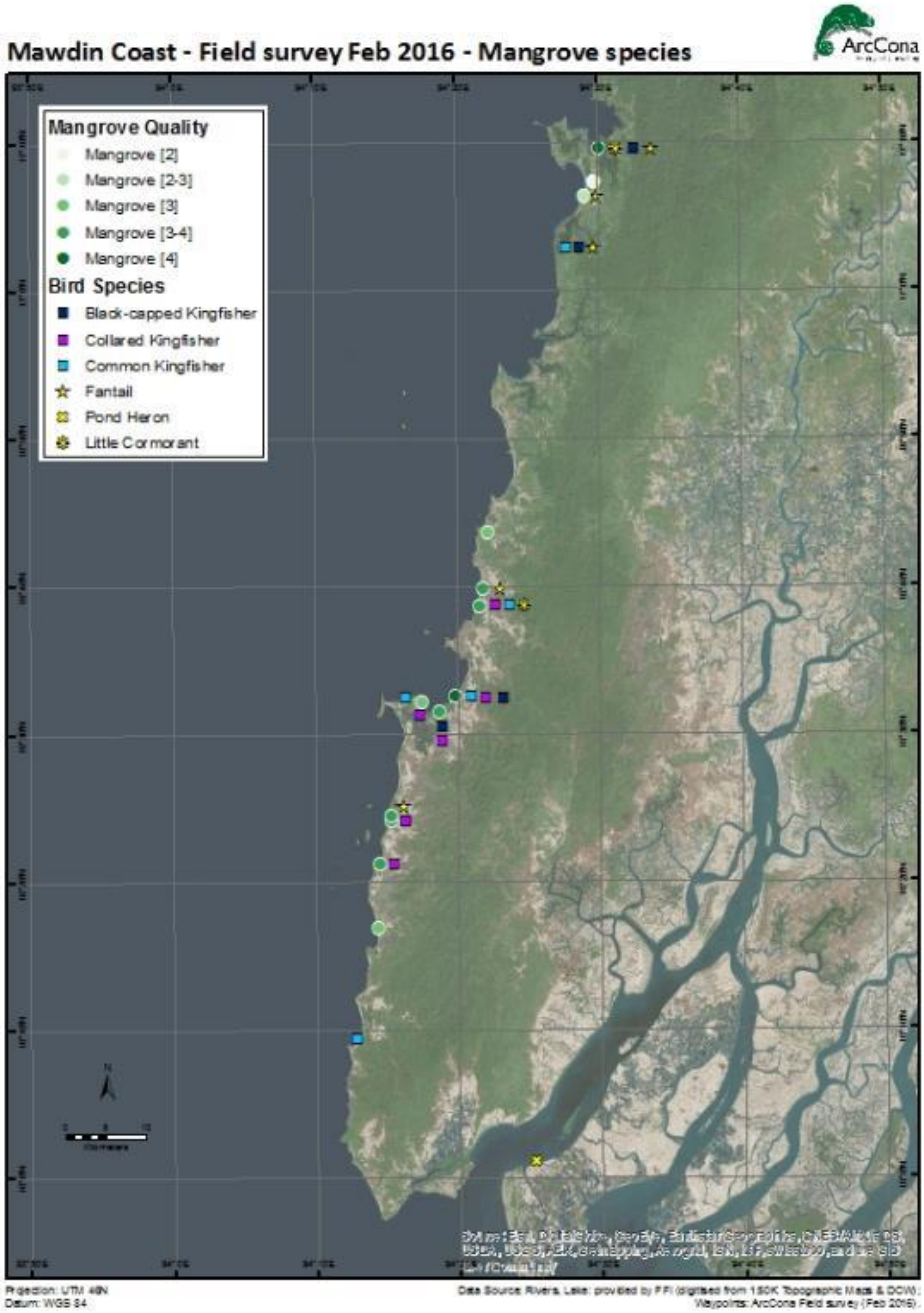


Figure 6.3: State of degradation of mangrove communities from rapid assessment on Mawtin Coast (categories shown in Table 4.1), and species of birds observed in mangroves in February 2016.

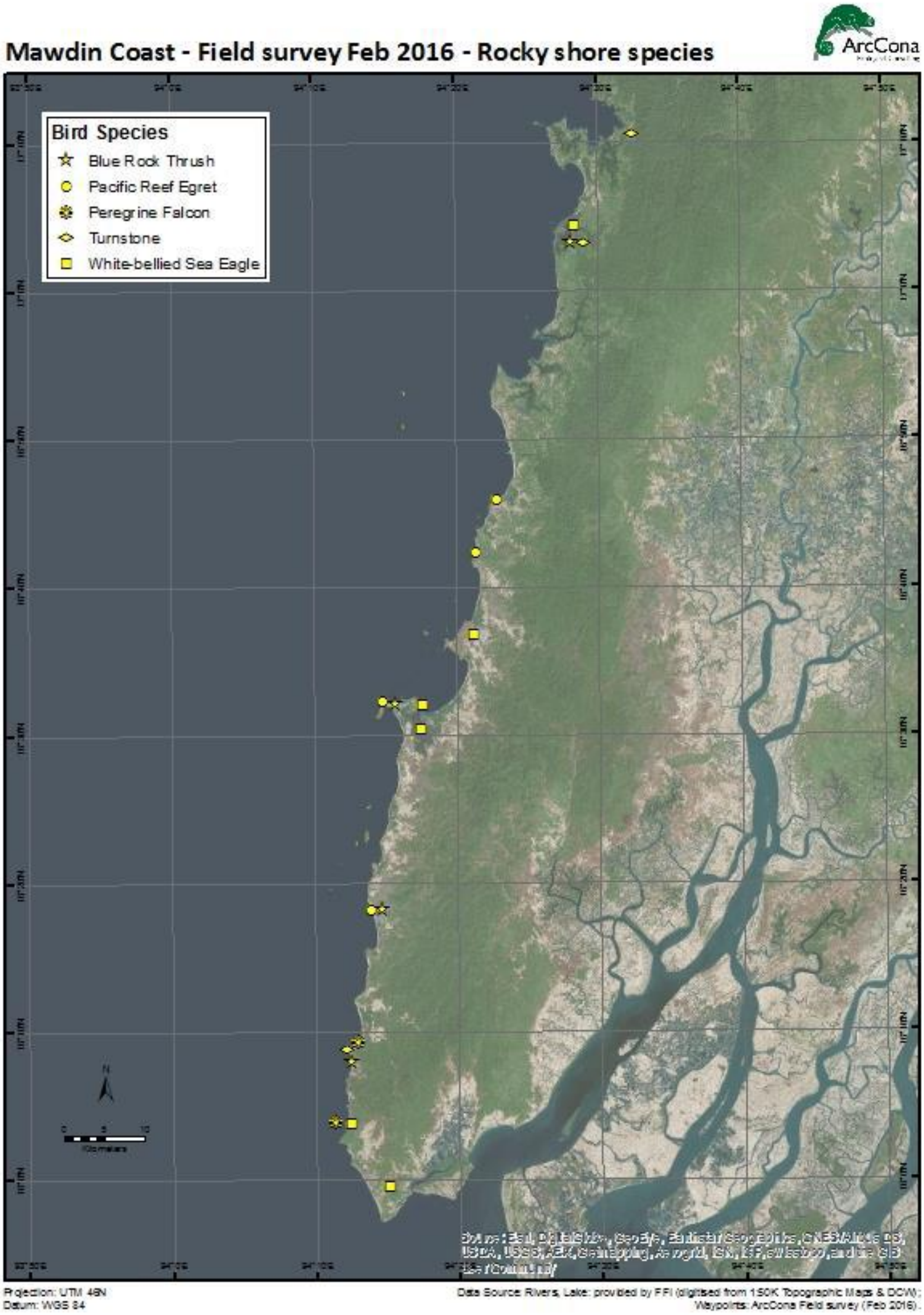


Figure 6.4: Birds found on rocky shores in the Eastern Ayeyarwady Delta and Mawtin Coast in February 2016.

iv Dry Forests

Dry forest areas are often found behind beaches or directly above rocky shores. These are the prime habitats for the elephants in the region. Dry forests are widely distributed and are close to the shore near the southern, less populated coast. These forests are important for various forest birds. Even though our main focus was on the actual coastal habitats we did survey those dry forest areas when they were close to the coast. Appendix 4 includes several species that were associated with these dry forest types only. The dry forest areas near Nga Yoke Kaung were particularly rich in species, with several cuckoo species, birds of prey, parakeet and passerines.

v Site comparisons

Phone Taw Pyae beach and adjacent Saka Khaing Gyi Island are important for migratory waterbirds but also other wintering migrants such as falcons, harriers and other birds, migrating from Southern Siberia and China. It was surveyed in December 2015 (Saw Moses and Zockler, 2015), and for comparison purposes the numbers of some species recorded in 2015 and 2016 are included here (Table 6.2).

Table 6.2: A comparison of numbers of important birds in Phone Taw Pyae Beach, Myanmar, between December 2015 and February 2016 (-,not seen; CR, Critically Endangered; EN, Endangered; NT, Near-Threatened;. VU, Vulnerable. IUCN Red List categories).

Globally threatened Bird Species	Numbers Dec 2015	Numbers Feb 2016
Aquila clanga (VU)	**1**	**-**
Numenius arquata (NT)	120	-
Limosa lapponica (NT)	1	5
Limosa limosa (NT)	-	400
Calidris tenuirostris (EN)	8	-
Calidris ferruginea (NT)	150	200
Calidris pygmeus (CR)	1	-
Calidris ruficollis (NT)	600	120
Other species of importance		
Sterna albifrons	1000+	500+
Falco amurensis	1	-
Chlidonias leucopterus	-	4

6.3.2 Meinmahla Kyun and Eastern Ayeyarwady Delta islands, December 2016

In total 118 bird species were recorded in the Delta region in December 2016 (Appendix 4). This is considerably fewer than during previous trips (in January 2010, November 2013 and December 2015). This may be due to the limited time spent in the forest reserves. Five species were recorded for the first time. These were two waders, including the Great Thick-knee, which may have been breeding on Nga Mann Thaung. This would be ideally verified during a survey between February and April. The other new wader was the Asian Dowitcher, of which two birds were recorded in Ayeyarwaddy Division for the first time. This constitutes only the third or fourth record for Myanmar. A flock of at least eight White-winged Terns were observed in the waters of the Outer Delta. These birds are common in the Gulf of Mottanma and their presence is not surprising. Also a Rufous Woodpecker was recorded in Meinmahla Kyun Wildlife Sanctuary for the first time, and a few single Red-throated Pipits were noted on Gadon Galay Island.

Three endangered species, nine near-threatened species and one ranked as vulnerable were identified (Table 6.3). Most notable were the observation of one Spoon-billed Sandpiper and 46 Nordmann's Greenshank. Waterbird counts at the Eastern Delta Islands are recorded in Appendix 4.

Table 6.3: Globally threatened species (BirdLife International 2015) observed in Meinmahla Kyun Wildlife Sanctuary, Nga Mann Thaung Island and adjacent coastal wetlands in December 2016, figures for 2013 in brackets. VU=Vulnerable; NT=Near Threatened; CR=Critical

Species	Scientific name	IUCN Category	Max No observed
Lesser Adjutant	*Leptoptilos javanicus*	VU	1 (5)
Black-headed Ibis	*Threskiornis melanocephalus*	NT	75 (110)
Great Thick-knee	*Esacus recurvirostris*	NT	1
Eurasian Curlew	*Numenius arquata*	NT	43 (120)
Bar-tailed Godwit	*Limosa lapponica*	NT	36
Asian Dowitcher	*Limnodromus semipalmatus*	NT	2
Nordmann's Greenshank	*Tringa guttifer*	EN	46 (48)
Great Knot	*Calidris tenuirostris*	EN	260
Red Knot	*Calidris canutus*	NT	5
Curlew Sandpiper	*Calidris ferruginea*	NT	250
Spoon-billed Sandpiper	*Calidris pygmeus*	CR	1 (1-2)
Red-necked Stint	*Calidris ruficollis*	NT	250
Brown-winged Kingfisher	*Pelargopsis amauroptera*	NT	2 (4)

6.4 Discussion

Mawtin Coast, February 2016

Waterbirds were relatively scarce on the Mawtin Coast, due to the lack of suitable or large mudflat areas on this coastal stretch. Only Phone Taw Pyae Beach in the Eastern Delta and adjacent mudflats near Haingyi held significant numbers of waterbirds and almost all near-threatened birds were observed only here. There was a high number (29) of the globally near-threatened Black-headed Ibis near Haingyi. There are high numbers of this species in other parts of the delta region (Saw Moses & Zöckler 2015). As the area was not easy accessible, the actual number is likely to be higher. Both sites, Phone Taw Pyae and Haingyi mudflats host large numbers of this species.

Two or maybe even three species were recorded for the first time in the Ayeyarwady Division. These included Long-legged Buzzard (*Buteo rufinus*), and one Asian Glossy Starling (*Aplonis panayensis).* An injured Sooty Tern *Sterna fuscata* was picked up by fishermen offshore waters. This appears to be the first official record for the region; however, there have been unconfirmed reports previously from the delta area.

Sandy beaches in the area are commonly used as roads by motorbikes, due to the poor roads and generally inaccessible nature of the coast. This would prevent the settling of any ground nesting species such as Thick-knees (*Burhinus* or *Esacus* spp.) or Pratincoles (*Glareola* spp.) or Terns.

Apart from Phone Taw Pyae Beach, the adjacent mudflat near Haingyi and the Pho Htaung Gyaing mudflat, the Mawtin coast does not host many significant wintering or breeding populations of

waterbirds, however, many water birds could have been missed due to the short time frame of this assessment.

Those areas in better condition have apparently been in private or community-based ownership and locally managed. White-throated Fantails were present in the less disturbed mangroves. Collared Kingfisher occurred in almost all mangrove areas down to condition level 3. However, they were rare in level 2 mangroves with trees not taller than 1-2 metres. Some of the mangrove areas were quite large and could have hosted rarer mangrove species such as Mangrove Pitta (*Pitta megarhyncha*) and Brown-winged Kingfisher (*Halcyon amauroptera*), but neither species has been recorded along the Mawtin Coast, whereas in similar surveys in Meinmahla Kyun in December and in the Myeik mangroves both species were very abundant.

Ayeyarwady Delta, December 2016

A declining trend in larger and medium sized waders was observed in the Outer Delta Islands, which is likely to be a reflection of continued hunting pressure to which all, including the critically endangered Spoon-billed Sandpiper, are subjected.

Most of the northern part of the Meinmahla Kyun Wildlife Sanctuary reserve is badly degraded by cyclones and by illegal human activities such as logging, fishing and other conflicts in resource management. The northern third of the island is heavily impacted by uprooted trees and no old growth mangrove remains. Even though the central and southern parts host much more mature trees and show a diverse community, there are strong indications of illegal logging, preventing the development of taller and more mature trees. A recent study by FFI confirmed that the vast majority of the area is actually not mangrove but occupied by a single species of palm (Lorenz *et al.* 2016). This is also partly reflected by the widespread lack of woodpeckers, barbets, hornbills, parakeets and other species dependant on mature trees.

We witnessed illegal firewood collection while in the area. Law enforcement appears marginal and has little effect. The constant and continuing cutting of branches has left the remaining mangroves in a poor state.

CHAPTER 7. CONSERVATION

Authors: Sue Murray-Jones and Filippo Carli

7.1 Introduction

Since 2016, we have provided a total of 4337 training days to Myanmar nationals, all aimed at building capacity for the marine science departments of Myanmar's universities. We ran 55 separate training events, from statistics and data analysis to swimming and diving, as well as some small group fieldwork. Much of training provided has comprised intensive hands-on field training, and university students and staff have collaborated in the collection of data on the marine and coastal habits of the Mawtin coast. To date, we have investigated 52 sites for coral across 150 km of coast and completed 87 coral transects. We counted 3538 fish on 80 transects. We completed 19 mangrove transects, collected seagrass data at 78 sites across 200 km and completed and mapped 126 transects using a towed video array.

In addition, we developed a program of small grants for Myanmar universities, which provide mentoring, training and assistance in conducting their own filed research. So far a total of 25 grants have supported 70 Myanmar staff and students in a variety of projects.

The biodiversity assessments were broad in scale and carried out across the entire Mawdin coast (from Mawdin Point in the south to a little north of Gwa in Rakhine State), but were detailed enough to allow us to identify the areas of highest ecological value based on key parameters of habitat quality such as percent cover and diversity for coral communities, seagrass beds and mangrove habitats. The key outcome of this work has been to develop a list of priority areas for consideration of protection. A total of seven locations were deemed to be representative of the coastal habitats of this area. These are all under different levels of pressure and some have been flagged as likely for future development.

In this chapter, we first discuss the priority areas for protection for the Mawtin coast of Myanmar, and then outline the main threats to the marine and coastal habitats of this area. We make some recommendations to ameliorate these threats.

7.2 Priority areas for protection on the Mawtin Coast

Some areas considered important for protection on the Mawtin coast are summarized in Table 7.1. Areas were initially identified during Phase I of the Mawtin coast partnership as potentially important. Efforts during Phase II were focussed on first confirming which areas were the key biodiversity areas for the Mawtin coast, and then collecting data from these to provide baseline data. Areas were ranked in order of priority based on the factors laid out in Table 7.1.

Table 7.1: Summary table collating biodiversity and resilience data for areas surveyed as part of the Mawtin Coast Biodiversity partnership between 2016 and 2019.

PRIORITY	KBA	HABITATS				THREATS		THREAT AMELIORATION
Rank	**Area**	**Seagrass**	**Mangrove**	**Coral**	**Fish**	**Existing tourism**	**Threats**	**Known level of threat management**
1	Ma Gyi	Extensive, biodiverse, dense areas, known dugong habitat	Extensive biodiverse communites, effective local restoration project. Moderate logging.	Biodiverse, mixed patch reefs, highest coral recruitment observed but high coral disease level	Sparse, poor diversity	Moderate and growing with new bridge over river at Shwethaungyan	High fishing pressure, tourism, resort development, collection of wood from mangroves	Some, especially mangroves. NGO/Uni Pathein paying villagers to restore mangroves rather than collecting wood. Presence of Uni of Pathein Field Station helps regulate local activity.
2	Pho Htaung	Extensive, diverse, both inter- and sub-tidal, dugong habitat	Extensive communites, more remote, less logging than most areas.	Nil	Sparse	Minimal but likley to increase as Shwethaungyan bridge will make access easier	Proposed industrial development, fishing, logging of mangroves	Remoteness of area helps keep impacts lower.
3	Bird Islands	Nil	Nil	Only true coral reef accretion observed, most diverse coral communities found on Mawdin coast	Moderate numbers, reasonably diverse	High	Tourism, boat anchoring, collection of coral and other marine "souvenirs", moderate fishing pressure	Some informal protection from local tour operators
4	Nyo Yoke Kaung	Small patches to the north, appear to be seasonal.	Extensive but in poor condition, heavily logged	Small amounts of coral on islands but limited in extent. Moderately turbid due to proximity to the Ayeyarwady Delta to the south.	Not surveyed	High: local land-based tourism based around National Tourist Monument, Gaw Yin Gyi I.	Tourism, fishing, proposed deep water port and other industrial development	None known, other than a very active local village Environment Committee who are partnering with Pathein University Marine Science Department
5	Gwa area	Extensive, with high percent cover. Mostly intertidal.	Some rare species and old trees on Gwa Township I.	Mixed coral/rocky reef communities, diverse on offshore reefs	Moderate numbers, reasonably diverse	Minimal	High fishing pressure	None known
6	Jadalet/ Bawmi Aww	Some seagrass observed, however no extensive meadows. Patchy.	Extensive, but not surveyed due to difficulty of access	Mixed coral communities , high diversity, moderate coral disease	Sparse, poor diversity	Minimal	Very high fishing pressure	None known
7	White Sand I, Chaung Tha	Some areas of seagrass, appear to be seasonal in abundance, patchy.	Nil	Extensive coral communities, showing signs of anchor damage and tourism	Sparse, poor diversity	Very high, mostly local tourism	Tourism, resort development, boat anchoring, collection of coral and other marine "souvenirs", fishing	Some informal protection from local tour operators

7.3 Threats

i Nutrient loading

The increased availability of organic matter and nutrients in more inshore areas, particularly during the wet season, may explain the higher prevalence of disease on those reefs close to shore (see Chapter 2). Lack of catchment management can impact marine habitats adversely in terms of disease, recruitment, direct smothering by sediment, toxins, and impacts from plastics. It is well established that nutrient loading can severely impact coral, seagrass and mangrove habitats (e.g. D'Angelo and Wiedenmann 2014; Lapointe et al. 2004; Lovelock et al. 2009). Lack of sewage treatment options in Myanmar mean the urban drainage systems acts as semi-open sewers (Asian Development Bank 2013). Raw sewage and septic tank effluent flow through the roadside drains, into rivers and out to sea.

The condition of coral reefs further offshore which have lower impacts from human activities (other than fishing) indicate that managing these impacts will improve reef health and human livelihoods in Myanmar, as well as preventing extensive loss of seagrass and mangroves as has happened elsewhere (e.g. Fox et al. 2007).

ii Plastics

Damage from monofilament nets and other plastics, as well as the dumping of plastic waste directly into the water, is very common in Myanmar. These practices contribute to coral disease (Lamb *et al*. 2018). A workshop on the assessment of marine litter held by FFI in 2017 (Cheshire and Murray-Jones 2017) outlined the common practice in Myanmar of "monsoon cleansing", where rubbish is discarded in creeks, streams and behind buildings, until the monsoon arrives and washes it into the sea. Plastic waste in Myanmar has increased greatly in recent years, with an estimated 119 tons moving down the Ayeyarwady every day (Jeske 2019). Cheshire developed criteria for the UN for assessing marine debris, and these have been updated for Myanmar (Cheshire and Murray-Jones 2017). More effort needs to be made to keep debris, especially plastics, out of the oceans.

Reef Check surveys include a quick assessment of litter. The Mawtin coast had slightly less litter than data from the Tanitharyi indicates (Figure 7.1) but both had substantially more than Malaysia (Chelliah 2012). Note that Peninsula Malaysia has very strict litter reduction programmes (pers.comm. J. Hyde, Reef Check Malaysia).

There are some beach clean up programmes running in tourist areas such as Ngwe Saung[8] and Chaung Tha[9], which hopefully will be expanded and continued.

[8] https://www.facebook.com/pg/myanmarbeachcleanup/events/

[9] https://www.mmtimes.com/news/yangon-activists-kick-clean-beach-campaign.html

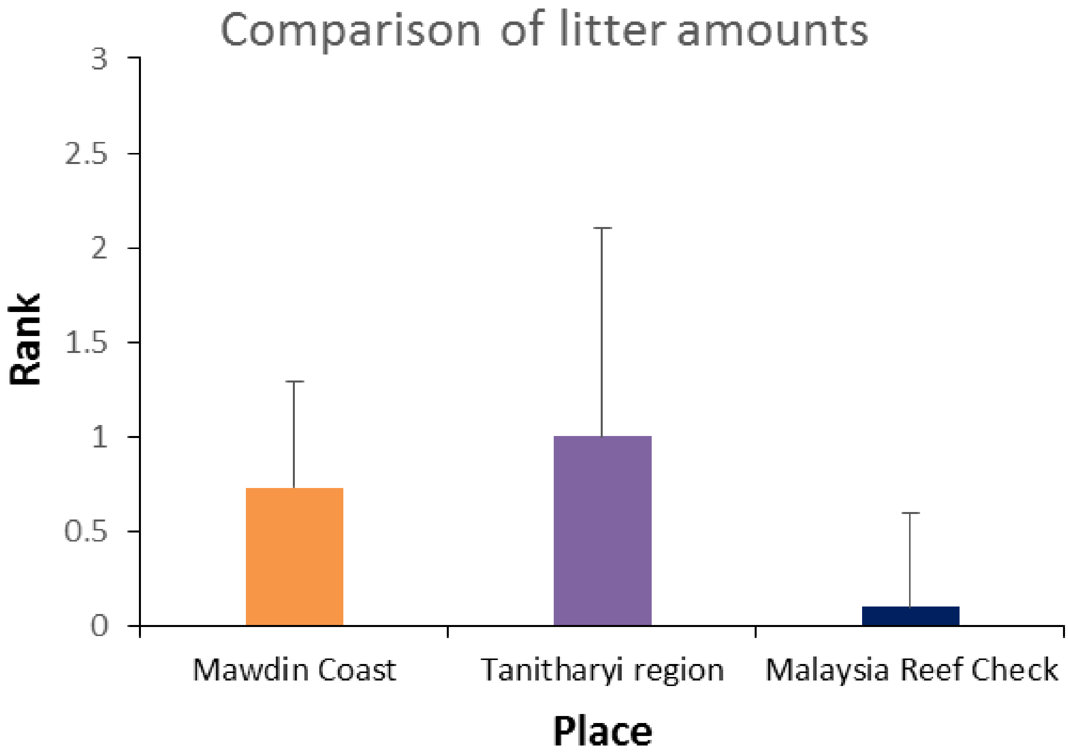


Figure 7.1 Ranked comparison of litter amounts from Reef Check data from two regions of Myanmar and combined data for Malaysia (mean rank±SD).

iii Fishing

There is widespread overfishing, exacerbated by ecosystem degradation in Myanmar. It has been suggested that 80% of global fisheries could collapse by 2030, affecting over 3 billion people worldwide (FAO, 2014). Myanmar accounts for around 62% of the global catch, and has the fastest increase in fishing production of any large fishing nation (FAO, 2014). That fishing be done sustainably is crucial for Myanmar, with an estimated 275 million people living within 30 km of coral reefs (Burke et al., 2011). More than 90% of coastal communities in Myanmar rely on reef fish and the productivity of the nearshore fishery for well-being (FAO, 2014), apart from their role in generating income, coastal protection and cultural importance.

Management and monitoring of fishing effort are two of the strongest tools for reducing impacts to coral reefs and other habitats, and establishment of monitoring programmes in partnership between fisheries authorities, all relevant fishery sectors and the conservation/management community is essential. Protection of biodiversity and maintaining habitats for alterative livelihoods, such as tourism is also critical.

While fish counts on transects on the Mawtin coast were higher than for the Tanitharyi (Howard 2014), numbers of larger fish were low, particularly on more accessible inshore sites. No sharks, turtles, mantas, marine mammals or any other rare animals were seen on any dive or snorkel, nor from any boat *en route* to dive sites, with the single exception of two Hawksbill turtles on a transect on the north side of North Bird Island in December 2016. Only one elasmobranch, a Blue-spotted ray, was observed in all dives. No Humphead wrasse, Bumphead parrot fish or Barramundi cod were seen, either on or off transect, and only three large grouper (over 50cm) were seen, on a single site on the north side of North Bird Island in December. A single Moray eel was seen at each of Thazin Village, Chaung Tha (White Sand

I), and South Bird I. Note that these indicator species are a draw for scuba divers and loss of these species could be detrimental to any tourism ventures.

iv Coral ecosystems

The health of more inshore reefs in the region appear compromised. While some sites had good coral communities, others showed unmistakable evidence of past mortality. There was a general absence of fish and high presence of sea urchins at some sites, suggesting high fishing impacts, and high levels of disease in some areas. All areas had evidence of high fishing pressure, such as net fragments and line entangled with the coral.

Corals that have been damaged (from dynamite, diving, tourism, boat anchors etc) are more susceptible to disease (Hughes and Connell, 1999; Lamb et al., 2014). While dynamiting appears to be rare on the Mawtin Coast, bleach and cyanide fishing are suspected, which can also harm corals (Jones and Steven 1997).

Anchor damage is widespread. The coral resilience reports (True 2016; 2019, summarized in Chapter 2) note that the burgeoning tourism industry in areas like White Sand I and the Bird Is off Ngwe Saung is bringing many local tourists to see the coral. As they invariably anchor in the middle of the most sheltered areas (which have the best coral), they destroy extensive amounts of coral.

Reef Check surveys include counts of abandoned, lost or otherwise discarded fishing gear (Appendix 2), which serves as a proxy for fishing effort. The score was very high for some sites on the Mawtin Coast (Figure 1.2) , especially in the more offshore sites where fish numbers were higher (note that the weather had been extremely rough prior to the December 2016 surveys, which may have agitated out some of the debris, accounting for the lower scores for the Bird Is in December 2016). The presence of discarded or snagged fishing nets over the reefs may have negative effects on coral growth and recruitment as many of them were observed covered in algae and smothering the substrate.

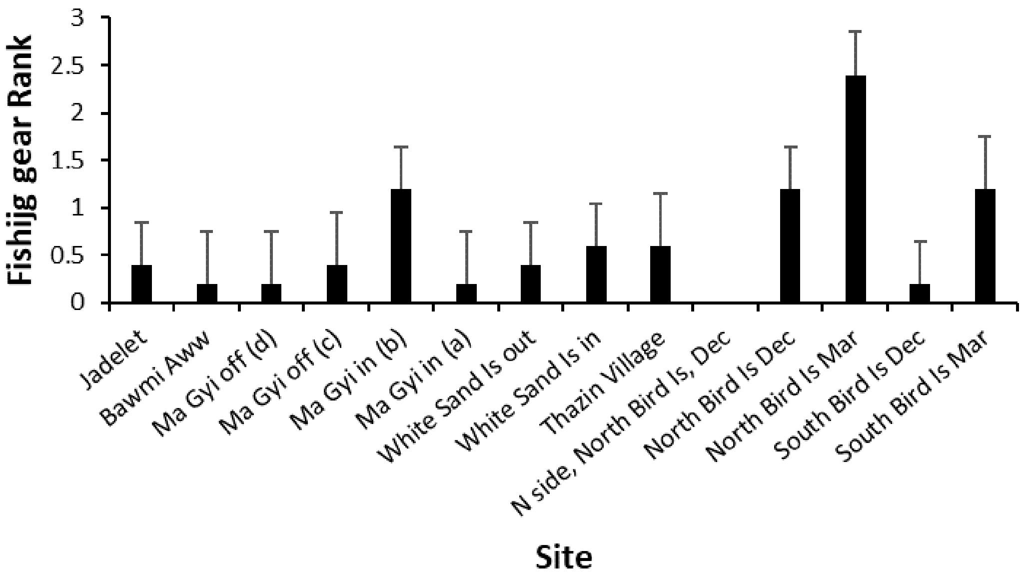


Figure 1.2: Ranked amount of broken or discarded fishing gear on Reef Check transects for the Mawtin Coast in 2016 (mean rank ± SD): 0 = none, 1 = low, 2 = medium and 3 = high.

There is also a need to stop all forms of Illegal fishing, particularly the use of chemicals, and targeting of sharks and rays, which appear to have been severely impacted in Myanmar. Anecdotal evidence suggests that levels of illegal, unreported and unregulated fishing are high on the Mawtin coast, and studies are needed to assess this.

Invertebrates: Reef Check surveys include assessing a suite of indicator invertebrate species (see Appendix 2). *Diadema* were the most common of all the invertebrates recorded with 24 (±46, se) individuals per 100m^2 transect, but some sites had up to 1000 per transect (see Figure 2.5). No banded coral shrimp, holothurians, collector urchin, triton shells or crown-of-thorns starfish were seen on transect, and only a few very juvenile lobsters. The results from the invertebrate surveys showed a landscape dominated by long spined sea urchins and depauperate in other invertebrates. These results are similar to Malaysia and Indonesia where only *Diadema* were recorded in high numbers while the indicator invertebrates were rarely observed more than once per transect (Habibi et al., 2007; Yewdall, 2013). Low numbers of indicator species have been blamed on overfishing for both the aquarium trade and as a food source.

Howard (2014) recommended a ban on compressor fishing given its impact on sea cucumber and lobster populations, and suggested that sustainable mariculture techniques/programmes for sea cucumber farming be investigated for small fishing communities.

v Seagrass

Soe Htun et al. (2002) suggested that there were no stresses in the meadows of seagrasses in coastal areas of Myanmar prior to 2002, considering them to be in pristine climax conditions. In more recent years, however, stresses are now increasing with increasing coastal development in Myanmar. Issues such as smothering, from land slides where forest areas have been cleared to changes in sediment movement due to the building of sea walls to protect resorts and other coastal assets, are common. In general seagrass beds in Myanmar are exposed to a number of threats including runoff from cities and towns and hazardous wastes and oil dispersals released from industrial zones located near seagrass. Bottom trawlers also operate directly through seagrass beds targeting shrimps and other marine species destroying these habitats.

Seagrasses are well known to be nursery areas for fish, including many targeted species, and including coral reef fish (e.g. Dorenbosch *et al*. 2005, Heck *et al*. 2003, Nagelkerken *et al*. 2002), as well as having a strong role in coastal protection (Ondiviela 2014), even when heavily grazed by turtles (Christianen 2013). Hence their protection is very important.

vi Mangroves

The value of mangroves has gone unrecognized for many years and the forests are disappearing in many parts of the world. As discussed in Chapter 4, some of the mangroves surveyed in 2018 were in such a bad state that mangrove specialist Stephano Cannicci considered there was no point to setting up permanent monitoring transects in the locations studied (Cannicci 2018) These impacts are likely to continue, and worsen, as human populations expand further into the mangroves. In regions where mangrove removal has produced significant environmental problems, efforts are underway to launch mangrove agroforestry and agriculture projects. Loss of mangroves is well known to increase the impact of tropical cyclones, and it has been suggested that many lives could have been saved in Myanmar during Cyclone Nargis in May 2008 if mangroves had been more intact (Spalding *et al.* 2010).

Mangrove systems require intensive care to save threatened areas. So far, conservation and management efforts lag behind the destruction, there is still much to learn about proper management and sustainable harvesting of mangrove forests. In some areas the health and productivity of the forests have declined significantly. The causes of these losses differ from habitat to habitat but are generally tied directly or indirectly to human activities. Case-by-case study is required to determine the most effective remedial measures. Where degraded areas

are being regenerated, continued monitoring and thorough assessment must be done to help the recovery process to be understood. The role that mangrove forests in Myanmar play in carbon capture and storage, and the concept that Myanmar can earn international money for protecting its mangroves, is attracting much attention.

7.4 Conservation Recommendations:

There are currently limited protection measures for marine and coastal habitats in Myanmar, and there are no protected areas on the Mawtin Coast. A number of recommendations in this section address the issues outlined above. Note that a spatial management approach is necessary to address these issues sufficiently and allow for competing resource use issues.

i Nutrient loads

Nutrient loads in the marine and nearshore coastal areas represent a significant threat to seagrasses, coral and mangrove ecosystems. Unregulated developments and disposal of effluent into coastal and estuarine waters are big issues.

- A catchment management approach to nutrient loads is needed.
- All new resorts development should manage sewage properly, and this needs to be enforced.

ii Plastics

There is no doubt that Myanmar urgently need some form of sustainable waste management system and storm water management to ensure less plastic enters the environment. There are many attempts world wide to prevent waste, from taxes and deposits on single use containers, plastic bag bans and levies, educational campaigns (funded through the plastic tax and levies), reuse campaigns etc. For Myanmar, some steps might include:

- Reduction at source: Many countries have banned single use plastic. Successful bans must be accompanied by awareness programs and initially focus on specific sectors (large retailers, food and beverages, etc.). Currenly large supermarkets in Yangon have a “plastic bag ban” once monthly or weekly, but this is rarely enforced or even encouraged by shop assistants.
- Marine debris assessments: The Myanmar governments (both regional and union) should encourage Clean Up days and annual assessments of the amount and sources of marine debris (as per Cheshire and Murray-Jones 2017).
- Undertake comprehensive land-use planning for the terrestrial landscape adjacent to the sensitive areas and institutionalise land-use practices which minimize runoff (also helping to prevent erosion and run off of chemicals used in agriculture and mining).

iii Fishing

Management and monitoring of fishing effort are two of the strongest tools for reducing impacts to coral reefs and other habitats. Monitoring programmes in partnership with fisheries authorities, all relevant fishery sectors and the conservation/management community are critical.

- The Myanmar Marine Fisheries Law of 1990 prohibits the use of explosives for fishing. Although the amount of dynamite fishing has apparently reduced in the past few years its use is still wide spread in some areas on Myanmar. Stricter punishments need to be given to those flaunting the well-known law and source of the explosives identified so that action can be taken to deal with the trade.
- Illegal fishing, including the use of chemicals such as cyanide and bleach, and targeting of sharks and rays, are huge issues. It is recommended that FFI Myanmar undertake studies to assess the extent of illegal, unreported and unregulated fishing on the Mawtin coast, and work with the Government of Myanmar on ways to reduce the impacts of illegal fishing.
- Inshore bottom trawling is a threat to benthic ecosystems and it is currently forbidden by Myanmar law. A Vessel Monitoring System is being developed for the whole country

and it is recommended that the Department of Fisheries shares information with universities and conservation organisation to inform conservation strategies.

- There should be size and bag limits for commercial species such as snapper and grouper to ensure juveniles are allowed to mature and reproduce before being harvested.
- Howard (2014) recommended a ban on compressor fishing given its impact on sea cucumber and lobster populations, and suggested that sustainable mariculture techniques/programmes for sea cucumber farming be investigated for small fishing communities in the Tanitharyi, and these recommendations should also apply to the Mawtin coast.
- The conservation status of fishes on the Mawtin coast has not been studied. It is recommended that FFI Myanmar, in partnership with the IUCN Global Marine Species Assessment Project to conduct a Regional Red List workshop to train FFI and university staff in IUCN Red List assessment methodology and to assess the extinction threat to all species in the region.
- The impact of discarded fishing nets not only effects the reef directly but also floating ghost nets can still catch fish and other marine life for decades into the future as well as being a nuisance for boat propellers: Ghost nets need to be reported, community awareness increased and clean-ups using volunteer divers initiated (the Myanmar Ocean Project is attempting to do this and has a web site set up[10]).
- Management for recovery and maintaining resilience should be a top priority. As we do not have any understanding of recruitment dynamics or sources of recruits of fish in Myanmar, this is an area that needs some research in order to identify and protect fish nursery grounds.

iv Anchoring damage

Given the number of fishing boats and the ever increasing numbers of tourism boats, in particular around coral areas like Chaung Tha and the Bird Is, anchor damage is a real issue.

- An awareness campaign targeting boat operators about the importance of reefs to the fisheries and to tourists is required.
- The installation of appropriate mooring buoys in sensitive areas with high boat traffic is essential, allied to an educational campaign.

v Marine souvenirs

Wherever there is local coastal tourism, there are nearly always long rows of shops selling coral, shells and other invertebrates, and a myriad of types of dried fish.

- There needs to be an education campaign for tourists and locals around unsustainable harvesting and its impacts, and regulations regarding the collection of live material for souvenirs.

vi Coral reefs

- With no understanding of larval dispersal and coral recruitment dynamics, there is an urgent need for studies to understand where recruits of coral and associated invertebrates are coming from, allowing protection of these areas.

vii Seagrass

- Key seagrass areas should be included in marine protected areas.

[10] http://www.myanmarocean.org/

- Ensure seagrass conservation is included in any coastal development projects and in all regional/state development plans.
- Improve public knowledge and recognition of the importance of seagrass habitats through nationwide education and awareness programmes targeting policy and decision makers, fishers and local communities and those involved in activities which impact seagrass beds.
- Undertake further detailed research on seagrass habitats including surveys of the ecosystem services provided by seagrass beds with a special focus on their importance to fisheries.
- Provide financial and technical support to various Myanmar institutions such as government departments and universities, including capacity development for community-based biodiversity conservation efforts.
- Regularly monitor the status of seagrass ecosystems along the coast of Myanmar including on ground surveys and satellite remote sensing analysis.

viii Coastal Development

The Mawtin coast is an exposed coast, subject to storm surges and large waves at times. Many already existing developments have been building sea walls to protect their investment from storm damage and rising sea levels; however, this robs areas on the downside of lateral drift of sand (pers. obs. SMJ). This has the potential to allow large areas of sand to become mobile and smother nearby reefs.

- The building of sea walls should require express permitting from regional government, and proposals should be considered by staff with coastal engineering skills.

ix Mangroves

- Protection should be given to areas such as Ma Gyi and Pho Htaung with reasonably intact mangroves.
- Education on the value of mangroves is required.
- Programmes such as the World View/University of Pathein's mangrove restoration project should be encouraged. This is a very active and successful mangrove restoration project near Pathein University's Field Station at Ma Gyi (pers. obs SMJ), where villagers are paid to grow and plant seedlings, in exchange for not harvesting mangroves for timber.

7.4.2 Marine Protected Areas

Establishing an ecosystem-based approach to fisheries management and developing a network of marine protected areas are both critical management tools in any discussion of the conservation and protection of marine and coastal assets. In 2016 a report was commissioned to provide a synthesis of progress made to date for the Tanitharyi area, identify remaining data gaps, evaluate the legal, policy, and institutional context, and suggest a road map to guide future activities for conservation management with a focus on establishing a network of MPAs in Myanmar with special reference to the Myeik Archipelago (Dearden 2016). Some of the discussion is relevant for the Mawtin coast and has been summarized below, with the appropriate recommendations. A full description of each recommendation can be found in Dearden (2016).

Existing legislation can be used to establish new Wildlife Sanctuaries, Marine National Parks, and Locally Managed Marine Areas. Myanmar's government is working with universities, civil society, private sector, and international organisation to develop a national policy on Marine Protected Areas. Such policy should become the framework for easier and faster development of new marine protected areas along the Mawtin Coast. The Department of Fisheries is working at Myanmar's new Marine Fisheries Law, which will include a range of fisheries co-management models. Within this framework, local fishing communities, with support from

international organisations, would collaborate with the government to identify the most suitable models for the area. Such a policy would complement the National Biodiversity Strategic Action Plan and the Ecotourism Policy and Management Strategy for Protected Areas, provide guidance for subsequent legislative amendments, and determine administrative arrangements necessary to implement a marine protected area network.

Although there is little information for the Mawtin coast (mainly university masters theses as well as reports generated through the Mawtin Coast Partnership), there exists enough information to identify some key biodiversity areas, which deserve protection. Key areas should include healthy and extensive seagrass meadows, coral reefs, and mangrove ecosystems. The opening up of coastal areas and the rapidly expanding tourism in the area provide a real opportunity for local employment, but this needs to be managed so as not to damage the very habitats that attract tourists. A summary table (Table 7.1) has been included in the next section, outlining the key biodiversity areas for the Mawtin Coast and their ecosystem attributes.

Overall, mangroves and allied mudflats and their fauna should be a very high priority for protection due to their remarkable diversity and international conservation significance, the high degree of threat currently being experienced (see Chapter 4), and the relatively high level of knowledge regarding the location of potential conservation sites. Mangrove habitats also have very high levels of ecosystem service provision.

As Dearden points out, it is well recognized that the success of any form of marine protected areas relies on support and ownership from local communities, especially in Myanmar where there is little enforcement capability. A community-based ecosystems approach, with a phased, adaptive, precautionary approach are key elements to in network establishment. For a full list of recommendations, see Dearden (2016). A shortened version of recommendations written by Dearden that apply to the Mawtin Coast include:

- New protected area legislation for Myanmar: finalise new marine protected area policy and convert it into legislation for Myanmar based upon current international best practice that includes a chapter specifically devoted to protected area network establishment and management. If this cannot be implemented then separate legislation should be enacted, taking into account the current amendments to the Fisheries Act to permit the establishment of locally managed marine areas.
- Maintain the locally managed marine area category of marine protected area under the Fisheries Act.
- Establish a vision for a marine protected area network in Myanmar to guide policy development.
- Develop, through a stakeholder-driven process, a marine protected area policy for Myanmar that provides a platform for legislative reform and guidelines for network and site implementation to meet national goals and international commitments. (ongoing – policy document expected to be approved in 2021).
- Assist the Myanmar government to meet their stated goal of protecting 15% of Myanmar reefs by 2020.
- Identify key biodiversity features and targets for their protection within the Myanmar marine protected area network for the Mawtin coast.
- Seagrass is an important habitat for both diversity and ecosystem services, the information for the Mawtin coast is relatively complete and identified sites should be included in marine protected area network design at the first opportunity.
- Identify the most effective sites for mangrove conservation, determine the necessary boundaries and work with local communities to develop effective protection regimes.
- Additional socio-economic surveys are needed to provide greater depth of understanding on issues identified in existing studies.
- Ban compressor fishing and undertake extensive outreach to explain to fishers why such a step is necessary.

- Design and implement a strategic tourism plan for the Mawtin coast that seeks to optimize conservation and community benefits and promotes ecotourism.
- Adopt a community-based approach to all aspects of marine protected area planning.
- Seek to improve adherence to existing fisheries regulations and enforce future protective measures by instigating a patrol system that could include communities, the Department of Fisheries, the Marine Police, the Navy and other potential partners.
- Establishment of an effective monitoring system (biophysical and socio-economic) from the outset is a necessary tool to implement effective adaptive management
- Approach the international donor community to provide funding to support the further design and implementation of an effective network of marine protected areas along the Mawtin Coast.

Underwater landscape, North Bird I (Salai Mon Nyi Nyi Linn)

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Appendices

Appendix 1: Summary of Small Grants Projects

Table 1: Small Grants Projects 2017

Project No	Participant	Project	Affiliation	Position/Type	Outputs	Number of participants
1	Thu Rein	Compare densities and abundances of seagrass Ma Gyi	Pathein	MSc project	MSc thesis	1
2	Maung Wei Phyo	Seagrass benthic fauna around Ma Gyi	Pathein	MSc project	MSc thesis	1
3	Mein Kant San	Seagrass fish communities around Ma Gyi	Pathein	Research project	MSc thesis	1
4	Tint Wai	Coral species diversity and distribution from MaGyi and Chaung Tha.	Pathein	MSc project	MSc thesis	1
5	Ei Thazin Naing	Distribution and Zonaton of mangrove species along the Gwa coast	Pathein	MSc project	MSc thesis	1
6	Hlaing Thazin Hun	Distribution and condition of mangrove plant species along the Kyeintali coast (S of Gwa)	Pathein	MSc project	MSc thesis	1
7	Nay San Lin	Distribution of mangrove plant species along the Mawdin Coast.	Pathein	MSc project	MSc thesis	1
	Nay San Lin	Shared fieldwork around Heiygi	Pathein	Research project	Report	1
8	U Soe Win	Comparison of distribution of mangroves between Myeik and Mawdin	Myeik	Research project	Report	1
9	Tin Zar Ni Win	Distribution of family Rhizophoraceae between Mawdin Coastal Areas and Myeik coastal areas	Myeik	MSc project	Report	1
10	Dr Cherry Aung, Dr Khin Kay Khaing, Dr Thu Thu Min, U Thuya Kyi Zin, U Thura Tun, Daw Linn Linn, Carl Redder and Salai Salai Mon Nyi Nyi	Underwater habitat mapping on the benthic communities : Bird Is, Ngwesung, Chaung Tha, and Nya Yoke Kaung	Pathein	Run as training for FFI and Pathein staff.	Maps of study area with habitat classifications. Report and manual on how to use camera	8
11	Daw Tin Tin Kyu	Estimation of soil organic carbon percentage of mangroves/ wetlands of Mawdin Coastline	Myeik	Lecturer, research project	Report	1

Table 2: Small Grants Projects 2018

Project No.	Participant	Project	Affiliation	Position/Type	Outputs	Number of participants
12	Dr Thu Thu Min, Prof Cherry Aung, MsC students (Aung Myo San, Phyo Zaw Oo and Aung Yair Yint Oo.). Thaung Htut WCS, and Salai, FFI	Video habitat mapping around Ma Gyi	Pathein U + WCS and FFI Staff	Lecturers and students, NGO staff. Research and training.	Maps, report, user manual	7 Table 7.1:
13	Dr Khin Mg Naing + Aye Aye San	Impacts of water quality on phytoplankton abundance and community	Pathein	Lecturer and MSc student	Report, MSc thesis	2
14	Dr Khin Mg Naing	Impacts of water quality on zooplankton abundance and community	Pathein	Lecturer	Report	1
15	Prof Cherry Aung, Dr Chaw Thiyi Pyae Phyo Aye	Birds of Pho Htaung Gyi	Pathein	Professor	Report	1
16	Ma Zu Zu Miko Min	Describe the composition and distribution of epifauna associated with Mangroves in Pho Htaung Gyi	Pathein	MSc student	MSc thesis	1
17	Ma Nant Thae Su Hlaing (Su Su)	Describe the macrofauna of Ma Gyi and Pho Htaung Gyi Mangrove areas	Pathein	MSc student	MSc thesis	1

Table 3: Small Grants Projects 2019

Project No.	Participant	Project	Affiliation	Position/Type	Outputs	Number of participants
18	U Soe Htun and Moe Lwin Lwin	Seagrass training and set up permanent transects at seagrass sites around Lampi	Myeik	Assistant Lecturers	Report	2
19	Moe Lwin Lwin with Dr. Yin Yin Htay, Thin Let Let Wai, Nay Nan Nander Nwe, Phyu Phyu Thin	Survey of seagrass sites around Lampi	Myeik	Lecturers, students	Report, Published paper	5
20	Dr Yin Yin Htay, with Daw Moe Lwin Lwin, Ma Phyu Phyu Thin and Ma Thin Lett Lett Wai	Compare the species diversity and abundance of seagrass between three sites near Dawai	Myeik	Assistant Lecturers, MSc students	Report	4
21	Daw Lett Wai New, Daw Wai Zar Phyo, Daw Chaw Su Lwin, Daw Thinzar Lwin Lwin, Daw Thet Lyar Win	Mangrove epifauna - including a comparison of a mangrove restoration area with a non restored area, Ma Gyi	Myeik	Assistant Lecturers	Report, MSc thesis	5
22	U Aung Myo Hsan, PhD candidate	Studies on the Biomass and Organic Carbon Production in Seagrass Meadows around Magyi	Mawlamyine	PhD student	Report, PhD thesis	1

Appendix 2: Standard Reef Check Categories

Substrate Codes

HC	hard coral
SC	soft coral
RKC	recently killed coral
NIA	nutrient indicator algae
SP	sponge
RC	rock
RB	rubble
SD	sand
SI	silt/clay
OT	other

Fish

Butterflyfish
Haemulidae
Snapper
Barramundi cod
Humphead wrasse
Bumphead parrot
Parrotfish
Moray eel
Grouper (30-40, 40-50, 50-60 and > 60cm)

Invertebrates

Banded coral shrimp
Diadema
Pencil urchin
Collector urchin
Sea cucumber
Crown-of-thorns
Triton
Lobster
Giant clam (<10 cm, 10-20, 20-30, 30-40, 40-50 and >50 cm)

Impacts: Coral Damage/Disease/Bleaching/Trash

Coral damage: boat/anchor
Coral damage: dynamite
Coral damage: other
Trash: fish nets

Trash: general
Bleaching (% of population)*
Bleaching (% of colony)
Coral Disease (% colonies affected)
Black Band
White Band

<u>Rare animals sighted (#/type/size)</u>
Sharks
Turtles
Mantas
Other

Appendix 3: Categories for habitat mapping

In 2018, after working with the University of Pathein to determine their needs, we used the following categories:

- Sand
- Rubble (small rocks or dead coral, unconsolidated)
- Coral (includes sort coral). If the screenshot comprised ≥50% coral, the classification was coral. If coral was <50%, but there was more coral than say sand, the classification would be coral/sand.
- Reef (consolidated rubble, rock, turfs and other encrusting organisms)
- Reef/coral (reef dominant)
- Coral/reef (coral dominant)
- Coral>50%cover
- High profile reef (>1.5 m in height within 500mm distance)
- High profile coral (>1.5 m with coral dominating)

In 2019, after discussion with the uNiversity and taking on board the experience from the previous surveys, the categories used were:

- Sand
    - Sand/Rubble (>50% sand, >30% rubble)
    - Sand/Rock (>50% sand, >30% rock)
- Rubble (small rocks or dead coral, unconsolidated)
    - Rubble/Rock (>50% rubble, >30% rock)
    - Rubble/Sand (>50% rubble, >30% sand)
- Rock
    - Rock/Rubble (>50% reef, >30% rubble)
    - Rock/Sand (>50% rubble, >30% sand)
    - Rock/Algae (>50% rubble, >30% algae)
- Algae
    - Algae/Rock (>50% algae, >30% rock)
    - Algae/Rubble (>50% algae, >30% rubble)
- Seagrass
    - Seagrass Dense (≥60% cover)
    - Seagrass Medium (>30, <66% cover)
    - Seagrass Sparse (≤30% cover)
- Coral
    - Coral Dense (≥60% cover)
    - Coral Medium (>30, <66% cover)
    - Coral Sparse (≤30% cover)
- Other

Appendix 4a: Bird species found in 2016

Appendix 4b: List of birds from the eastern Ayeyarwady Delta, February 2016

Bird species recorded from the eastern Ayeyarwady Delta and Mawtin Coast between 18-28 February 2016. Status on IUCN Red List included. NT=Near Threatened.

	Species		**IUCN Red List**
1	Red Junglefowl	*Gallus gallus*	
2	Yellow-legged Buttonquail	*Turnix tanki*	
3	Asian Openbill	*Anastomus oscitans*	
4	Lesser Whistling-Duck	*Dendrocygna javanica*	
5	Black-headed Ibis	*Threskiornis melanocephalus*	NT
6	Yellow Bittern	*Ixobrychus sinesis*	
7	Black-crowned Night-Heron	*Nycticorax nycticorax*	
8	Little Heron	*Butorides striata*	
9	Indian Pond-Heron	*Ardeola grayii*	
10	Eastern Cattle Egret	*Bubulcus coromandus*	
11	Grey Heron	*Ardea cinerea*	
12	Great Egret	*Ardea alba*	
13	Little Egret	*Egretta garzetta*	
14	Pacific Reef-Egret	*Egretta sacra*	
15	Oriental Darter	*Anhinga melanogaster*	NT
16	Little Cormorant	*Phalacrorax niger*	
17	Common Kestrel	*Falco tinnunculus*	
18	Peregrine Falcon	*Falco peregrinus*	
19	Osprey	*Pandion haliaetus*	
20	Long-legged Buzzard	*Buteo rufinus*	
21	Common Buzzard	*Buteo buteo*	
22	Grey-faced Buzzard	*Butastur indicus*	
23	White-bellied Eagle	*Haliaeetus leucogaster*	
24	Oriental Honeybuzzard	*Pernis ptilorhyncus*	
25	Black Kite	*Milvus migrans*	
26	Brahminy Kite	*Haliastur indus*	
27	Black-shouldered Kite	*Elanus caeruleus*	
28	Shikra	*Accipiter badius*	
29	Besra	*Accipiter virgatus*	
30	Crested Serpent-Eagle	*Spilornis cheela*	
31	Eastern Marsh Harrier	*Circus spilonotus*	
32	White-breasted Waterhen	*Amaurornis phoenicurus*	
33	Slaty-breasted Crake	*Gallirallus striatus*	

34	Pacific Golden Plover	*Pluvialis fulva*	
35	Grey Plover	*Pluvialis squatarola*	
36	Kentish Plover	*Charadrius alexandrinus*	
37	Lesser Sand-Plover	*Charadrius mongolus*	
38	Greater Sand-Plover	*Charadrius leschenaultii*	
39	Black-tailed Godwits	*Limosa limosa*	NT
40	Bar-tailed Godwit	*Limosa lapponica*	NT
41	Whimbrel	*Numenius phaeopus*	
42	Terek Sandpiper	*Xenus cinereus*	
43	Wood Sandpiper	*Tringa glareola*	
44	Common Sandpiper	*Actitis hypoleucos*	
45	Common Greenshank	*Tringa nebularia*	
46	Marsh Sandpiper	*Tringa stagnatilis*	
47	Common Redshank	*Tringa totanus*	
48	Red-necked Stint	*Calidris ruficollis*	NT
49	Curlew Sandpiper	*Calidris ferruginea*	NT
50	Broad-billed Sandpiper	*Limicola falcinellus*	
51	Ruddy Turnstone	*Arenaria interpres*	
52	Little Tern	*Sternula albifroms*	
53	Greater Crested Tern	*Sterna bergii*	
54	White-winged Tern	*Chlidonias leucopterus*	
55	Whiskered Tern	*Chlidonias hybrida*	
56	Sooty Tern	*Sterna fuscata*	
57	Brown-headed Gull	*Chroicocephalus brunnicephalus*	
58	Rock Pigeon	*Columba livia*	
59	Ashy-headed Green Pigeon	*Treron pompadora*	
60	Emerald Dove	*Chalocophaps indica*	
61	Spotted Dove	*Streptopelia chinensis*	
62	Red Collared Dove	*Streptopelia tranquebarica*	
63	Red-breasted Parakeet	*Psittacula alexandri*	NT
64	Vernal Hanging Parrot	*Loriculus vernalis*	
65	Plaintive Cuckoo	*Cacomantis merulinus*	
66	Banded Bay Cuckoo	*Cacomantis sonneratii*	
67	Asian Koel	*Eudynamys scolopacaceus*	
68	Green-billed Malkoha	*Rhopodytes tristis*	
69	Greater Coucal	*Centropus sinensis*	
70	Lesser Coucal	*Centropus bengalensis*	
71	Collared Scops-Owl	*Otus lettia*	
72	Asian Barred Owlet	*Glaucidium cuculoides*	
73	Large-tailed Nightjar	*Carprimulgus macrurus*	

74	Asian Palm-Swift	*Cypsiurus balas*	
75	Germain's Swiftlet	*Collocalia germani*	
76	Treeswift	*Hemiprogne sp.*	
77	Oriental Pied Hornbill	*Antracocerros albirostris*	
78	Indian Roller	*Coracias benghalensis*	
79	White-throated Kingfisher	*Halcyon smyrnensis*	
80	Black-capped Kingfisher	*Halcyon pileata*	
81	Collared Kingfisher	*Todiramphus chloris*	
82	Common Kingfisher	*Alcedo atthis*	
83	Little Green Bee-eater	*Merops orientalis*	
84	Chestnut-headed Bee-eater	*Mecops leschenaulti*	
85	Coppersmith Barbet	*Megalaima haemaccephala*	
86	Lineated Barbet	*Megalaima lineata*	
87	Streak-throated Woodpecker	*Picus xanthopygaeus*	
88	Indochinese Cuckooshrike	*Coracina polioptera*	
89	Ashy Minivet	*Pericrocotus divaricatus*	
90	Black-naped Oriole	*Oriolus chinensis*	
91	Ashy Woodswallow	*Artamus fuscus*	
92	Blue-winged Leafbird	*Chloropsis cyanopogon*	
93	Common Lora	*Aegithina tiphia*	
94	White-throated Fantail	*Rhipidura albicollis*	
95	Black Drongo	*Dicrurus macrocercus*	
96	Ashy Drongo	*Dicrurus leucophaeus*	
97	Bronzed Drongo	*Dicrurus aeneus*	
98	Greater Racket-tailed Drongo	*Dicrurus paradiseus*	
99	Hair-crested Drongo	*Dicrurus hottentottus*	
100	Black-nape Monarch	*Hypothymis azurea*	
101	House Crow	*Corvus splendens*	
102	Large-billed Crow	*Corvus japonensis*	
103	Racket-tailed Treepie	*Crypsirina temia*	
104	Rufous Treepie	*Dendrocitta vagabunda*	
105	Brown Shrike	*Lanius cristatus*	
106	Olive-backed Sunbird	*Cinnyris jugularis*	
107	Ruby-cheeked Sinbird	*Anthreptes simplex*	
108	Scarlet-backed Flowerpecker	*Dicaeum cruentatum*	
109	Little Spiderhunter	*Arachnothera longirostra*	
110	White-rumped Munia	*Lonchura striata*	
111	Scaly-breasted Munia	*Lonchura punctulata*	
112	House Sparrow	*Passer domesticus*	

113	Eurasian Tree-Sparrow	*Passer montanus*	
114	Plain-backed Sparrow	*Passer flaveolus*	
115	Baya Weaver	*Ploceus philippinus*	
116	Paddyfield Pipit	*Anthus ruufulus*	
117	Olive-backed Pipit	*Anthus hodgsoni*	
118	Western Yellow Wagtail	*Motacilla flava*	
119	White Wagtail	*Motacilla alba*	
120	Grey Wagtail	*Motacilla cinerea*	
121	Jungle Myna	*Acridotheres fuscus*	
122	Common Myna	*Acridotheres tristis*	
123	Chestnut-tailed Starling	*Sturnus philippensis*	
124	Glossy Starling	*Aplonis panayensis*	
125	Blue-Rock-thrush	*Monticola solitarius*	
126	Siberian Rubythroat	*Luscinia calliope*	
127	Eastern Stonechat	*Saxicola maurus*	
128	Pied Bushchat	*Saxicola caprata*	
129	Blue-throated Flycatcher	*Cyornis rubeculoides*	
130	Verditer Flycatcher	*Eumyias thalassinus*	
131	Taiga Flycatcher	*Ficedula albicilla*	
132	Oriental Magpie-Robin	*Copsychus saularis*	
133	White-rumped Shama	*Copsychus malabaricus*	
134	Bushlark	*Mirafra sp.*	
135	Oriental Skylark	*Alauda gulaula*	
136	Stripe-throated Bulbul	*Pycnonotus finlaysoni*	
137	Streak-eared Bulbul	*Pycnonotus blanfordi*	
138	Red-whiskered Bulbul	*Pycnonotus jocosus*	
139	Red-vented Bulbul	*Pycnonotus cafer*	
140	Black-crested Bulbul	*Pycnonotus melanicterus*	
141	Black-headed Bulbul	*Pycnonotus atriceps*	
142	Barn Swallow	*Hirundo rustica*	
143	Pacific Swallow	*Hirundo pacifica*	
144	Red-rumped Swallow	*Hirundo daurica*	
145	Greenish Warbler	*Phylloscopus trochiloides*	
146	Yellow-browed Warbler	*Phylloscopus inornatus*	
147	Dusky Warbler	*Phylloscopus fuscatus*	
148	Oriental White-Eye	*Zosterops palpebrosus*	
149	Pin-Striped Tit-Babbler	*Macronus gularis*	
150	Abbott's Babbler	*Malacocincla abbotti*	
151	Yellow-eyed Babbler	*Chrysomma sinense*	
152	Rufous-fronted Babbler	*Stachyris rufifrons*	
153	Puff-throated Babbler	*Pellorneum ruficeps*	

154	Grey-throated Babbler	*Stachyris nigriceps*	
155	Oriental Reed-Warbler	*Acrocrophalus orientalis*	
156	Pallas Grasshopper Warbler	*Locustella certhiola*	
157	Thick-billed Warbler	*Acrocrophalus aedon*	
158	Zitting Cisticola	*Cisticola juncoides*	
159	Common Tailordbird	*Orthotomus sutorius*	
160	Dark-necked Tailorbird	*Orthotomus atrogularis*	
161	Grey-breasted Prinia	*Prinia hodgsonii*	
162	Rufescent Prinia	*Prinia rufescens*	
163	Plain Prinia	*Prinia inornata*	

Appendix 4c: List of Birds from the eastern Ayeyarwady Delta Islands, December 2016

Bird species recorded from the Eastern Ayeyarwady Delta Islands between 3-8 December 2016, including previous survey results from January 2010, November 2013 and December 2015. Status as per BirdLife International 2015. NT=Near Threatened; VU=Vulnerable; EN=Endangered; CR=Critically Endangered.

	Species	**status**	**2010 (Jan)**	**2013 (Nov)**	**2015 (Dec)**	**2016 (Dec)**
1	Ruddy Shelduck		4			-
2	Grey Heron		30	26	2 to 5	17
3	Great Egret		70	140	110	100
4	Intermediate Egret		16		100	
5	Little Egret		?	120	40	
6	Black-headed Ibis	VU	120	35	8	75
7	Grey Plover		60	250	50	120
8	Pacific Golden Plover		30	3	10	10
9	Greater Sandplover		30	1500	150	150
10	Lesser Sandplover		3500	500	2000	1500
11	Kentish Plover		40	20	100	1000
12	Eurasian Curlew	NT	190	120	105	43
13	Whimbrel		10	70	10	160
14	Black-tailed Godwit	NT	400	16	-	-
15	Bar-tailed Godwit		110	30	20	36
16	Asian Dowitcher	NT				2
17	Northern Greenshank		50	50	12	20
18	Marsh Sandpiper		8	2	2	-
19	Common Redshank		600	250	240	160
20	Terek Sandpiper		150	30	20	30
21	Nordmann’s Greenshank	EN	8	26	48	46
22	Great Knot	EN	600	146	130	260
23	Red Knot	NT	120	12	5	5

24	Broad-billed Sandpiper		200	100	350	200
25	Curlew Sandpiper	NT	150	80	225	250
26	Red-necked Stint	NT	90	36	50	200
27	Little Stint			4		
28	Long-toed Stint				2	-
29	Spoon-billed Sandpiper	CR		1 to 2	-	1
30	Sanderling		20	20	15	5
31	Ruddy Turnstone		40	25	40	10
32	Pallas' s Gull		850	142	900	800
33	Heuglin's Gull			2	5	5
34	Brown-headed Gull		2800	90	500	2000
35	Gull-billed Tern		2		-	-
36	Little Tern		100	120	660	200
37	Common Tern		10			
38	Greater Crested Tern		170			
39	Caspian Tern		5	37	360	73
40	Whiskered Tern		800	500	2000	8

Data from Saw Moses and Zöckler, C. (2013, 2015) as well as current survey.

IF YOU HAVE ANY QUESTIONS OR WOULD LIKE MORE INFORMATION, PLEASE CONTACT:

FAUNA & FLORA INTERNATIONAL, MYANMAR PROGRAMME

Office: 34 D/9 San Yae Twin Street, Kaba Aye Pagoda Road, Bahan Township, Yangon, 11201, Myanmar.

Tel: +95 (0)973 194 749

www.fauna-flora.org